INSTRUCTION MANUAL

Serial Number ____________

TYPE 410 PHYSIOLOGICAL MONITOR

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070-0658-01
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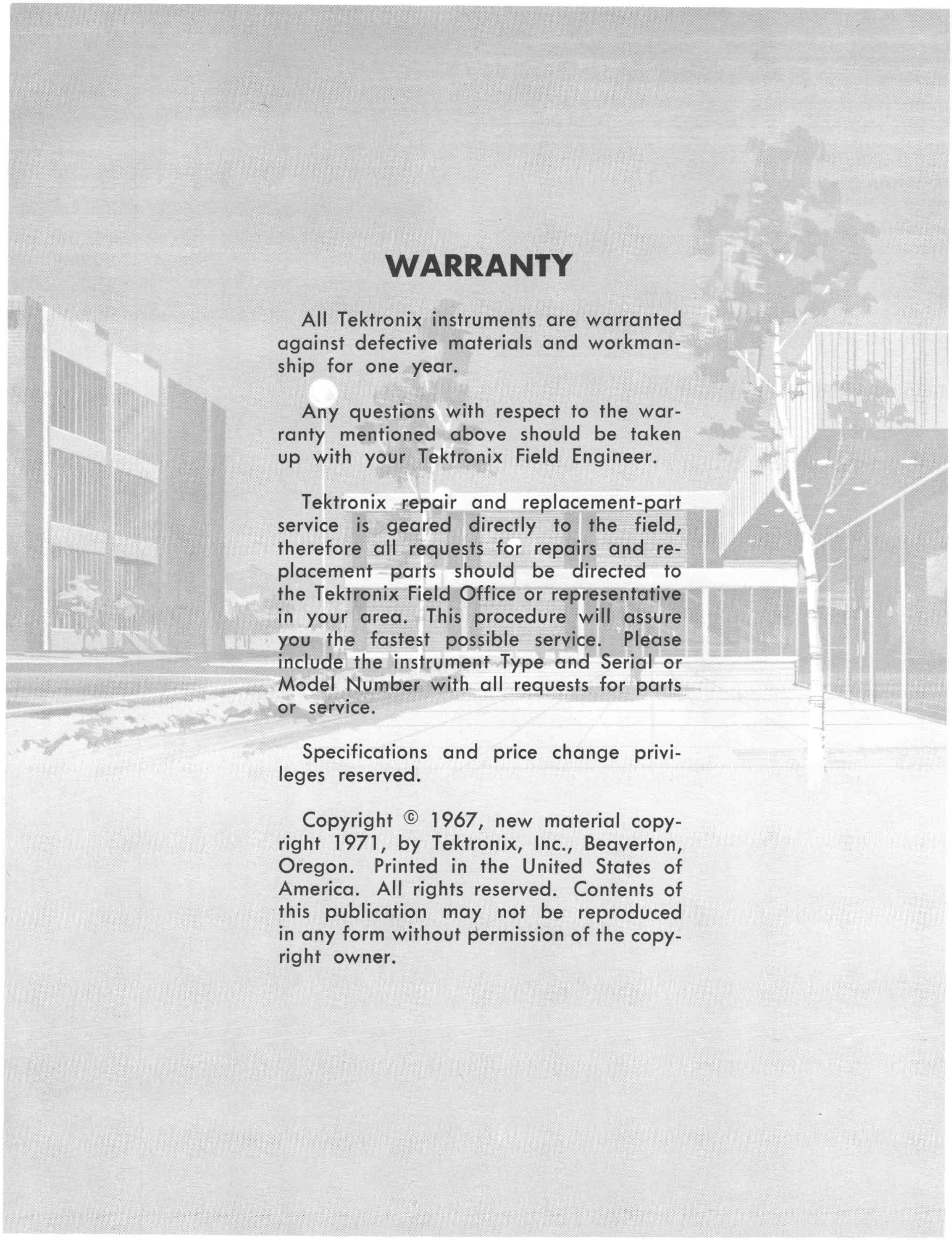


WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

INSTRUCTION MANUAL SUPPLEMENT
Type 410 Physiological Monitor
OPERATING PRECAUTIONS

INTRODUCTION:

The Tektronix Type 410 Physiological Monitor is a portable, battery operated oscilloscope designed for long-term monitoring of ECG, pulse-waveform and EEG. The instrument features solid state circuitry, providing added safety for the patient, as well as enhanced operating reliability. The Type 410 provides protection for the patient in several ways:

1. Battery operation, so that no power line connection is needed in critical applications.

2. Solid state circuitry, so that only low voltages and currents are needed in the signal input circuits.

3. Protective current-limiting devices in the input circuits, so that the input circuitry is protected from failure due to external causes. These same devices limit fault current to the patient in the unlikely event of multiple component failures within the Type 410 amplifiers.

It is necessary to carefully consider possible hazards to the patient and attending personnel when the Type 410 is used in conjunction with other electrical or electronic equipment. It is important that **all** operators of the Type 410 read and understand the following warnings related to applications of the Type 410. It is important that the subsequent explanations be carefully read, and the precautions carefully followed.

DANGER

DO NOT USE THE TYPE 410 WITH IMPLANTED OR CATHETER ELECTRODES

THE PROTECTIVE CIRCUITS CAN NOT LIMIT ELECTRODE LEAKAGE AND/OR FAULT CURRENTS TO VALUES SAFE FOR MONITORING WITH LEADS PLACED DIRECTLY IN OR UPON THE HEART.

DANGER

SERIOUS BURN AND SHOCK HAZARDS

SERIOUS BURNS OR FATAL SHOCK CAN RESULT WHEN THE TYPE 410 ELECTRODES PROVIDE A GROUNDING CIRCUIT FOR CURRENT FLOWING FROM OTHER EQUIPMENT WHICH MAY BE DEFECTIVE OR INCORRECTLY CONNECTED TO OR IN CONTACT WITH THE PATIENT OR ATTENDING PHYSICIAN. TEST ALL PATIENT-RELATED ELECTRICAL EQUIPMENT FOR PROPER OPERATION AND GROUNDING AND OBSERVE ALL INSTRUCTION MANUAL PRECAUTIONS BEFORE CONNECTING TYPE 410 PATIENT ELECTRODES.

DANGER

EXPLOSION HAZARD

THE TYPE 410 IS NOT INTENDED FOR USE IN THE PRESENCE OF FLAMMABLE ANESTHETICS. SERIOUS EXPLOSION CAN RESULT FROM OPERATION OF THE TYPE 410 IN THE PRESENCE OF FLAMMABLE ANESTHETICS. OBSERVE THE REQUIREMENTS OF NFPA CODE NO. 56, ART. 243 and 248, REGARDING USE OF PORTABLE ELECTRICAL EQUIPMENT IN ANESTHETIZING LOCATIONS; THE TYPE 410 MUST BE OPERATED AT LEAST FIVE FEET ABOVE THE FLOOR, AND ITS POWER CORD MUST BE DISCONNECTED. DO NOT REMOVE OR INSERT THE BATTERY PACK WHERE THE AIR MAY CONTAIN FLAMMABLE VAPORS.

SHOCK AND BURN HAZARDS, GENERAL:

In medical applications of electrical and electronic equipment, electrical fault current passing through monitoring electrodes connected to the patient may cause fatal shock or serious burns. These fault currents may result from defective, improperly grounded equipment, or they may occur in properly operating, but incorrectly connected, equipment. This includes not only the diagnostic and therapeutic equipment directly in contact with the patient, but also such items as electric lamps, powered beds, pumps, aspirators, etc., that the patient or the attending personnel may contact. The hazards to patients resulting from these equipment interactions are discussed by J. A. Hopps in his article "Shock Hazards in Operating Rooms and Patient-care Areas" in the August, 1969, issue of **Anesthesiology** magazine.

When the Type 410 alone is electrically connected to the patient the chance of fatal shock or serious burns is minimal; protective components and circuits in the Type 410 protect the patient from dangerous currents when external electrodes are used.

SHOCK HAZARD WITH IMPLANTED OR CATHETER ELECTRODES:

When electrodes are placed in or on the heart, the protective circuitry of the Type 410 will not limit leakage or fault currents to values that can be considered safe. A simple component failure within the Type 410, or a very small leakage current between the Type 410 and any other electrical device connected to the patient, might cause a fatal electrical shock through the implanted electrodes or catheters. Tektronix does not consider the Type 410 to be intrinsically safe in such applications.

BURN HAZARD WITH ELECTRO-CAUTERY UNITS:

When radio-frequency electro-cautery units are used in conjunction with monitoring devices such as the Type 410, the patient is exposed to the hazard of non-fatal burns. These burns are caused by the passage of radio-frequency (RF) cautery current through the monitoring unit electrodes. These RF currents may cause severe (second, and possibly third degree), localized burns at the electrodes. We know of no instance of electrocution attributed to such RF currents.

In a typical electro-cautery application, the patient is grounded through a butt-plate or conductive blanket which provides the return path to the unit for the RF current. Modern units have ground-fault detectors to prevent the flow of RF current should the butt-plate connection be ineffective. However, the effectiveness of such detectors may be questionable, and many units still in use do not have ground-fault-detectors.

If the patient grounding system for the cautery unit is defective, the monitoring device can become the ground return path for the RF current delivered to the patient through the cutting or cauterizing tool. This ground path can be effectively eliminated, minimizing the risk of patient burns, if the Type 410 is not connected to the power line and is not grounded, either through its ground post, its power cord ground, or its mounting stand. When the Type 410 is used in conjunction with an electro-cautery unit, the operator should observe these precautions:

1. Carefully check out the butt-plate or conductive blanket connection to the patient, and to the cautery unit as well. Unsatisfactory RF grounding is indicated by ineffective cutting or cauterizing, requiring higher than normal settings on the cautery unit. This has been substantiated by at least one case where electrode burns were reported.

2. Avoid placing Type 410 electrodes near the region on the patient where the cautery unit will be used.

3. Operate the Type 410 from its internal battery with the power cord disconnected, if possible.

4. Remember that if the cautery unit ground is ineffective, RF current burns can occur at any other place on the patient's body that makes contact to ground, such as on the operating table or other monitoring devices, or other grounded electrical equipment in the area.

SHOCK HAZARDS FROM OTHER ELECTRICAL EQUIPMENT:

When a line-operated, grounded Type 410 is connected to a patient who comes into contact with an ungrounded, defective (and thus electrically live) appliance, fatal currents can pass through the Type 410 electrodes and thus to the power ground. Such defective appliances may include electrically operated beds, lamps, etc. Any other electrical device connected to or in contact with the patient at the same time as the Type 410, can expose the patient or attending personnel to the danger of lethal shock whenever a ground fault, power line wiring fault, or internal equipment failure exists. Precautions to minimize such dangers include:

1. Careful, systematic, and regular examination and maintenance of all electrical equipment and appliances used on or around patients.

2. Careful and regular testing of power circuit grounding provisions.

In any case, danger to the patient is greatly minimized if the Type 410 is isolated from ground, and operated from its internal batteries without connection to the power line. This mode of operation is not always practical, as long term monitoring may exceed the battery's energy supply. Stands, carts or other mounting devices may also provide an electrical path to ground. Even when the Type 410 is carefully isolated from ground, one additional danger exists in this application. If electrically live equipment contacts the case of the Type 410, the patient may receive a lethal shock through the Type 410 electrodes. In such cases the ground return for the fault current is through some path, such as the bed, table, other monitoring device, or attending personnel. This danger can be minimized by careful maintenance of equipment on a regular basis, and careful examination and testing of power line grounding provisions.

EXPLOSION HAZARDS:

Although the Type 410 operates from low-voltage batteries, it does have internal high-voltage and energy-storage

circuits. Thus, the instrument itself cannot be considered safe for operation in the presence of flammable anesthetic vapors or gases, except as prescribed by the National Fire Protection Association in NFPA Code 56, Art. 243 and 248. These NFPA regulations should be carefully studied and observed. The Type 410 power cord must be disconnected, and the instrument must be supported at least five feet above the floor where flammable anesthetics are in use.

The same protective devices and circuits that limit electrode currents to the patient, also limit the energy available to the patient cable to levels defined by the instrument Society of America (in ISA RP 12.2-1965) as intrinsically safe from explosion hazard. This is the case even if multiple component failures occur within the Type 410. Thus, it is allowable for the Type 410 patient cable to extend into the hazardous area.

CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

WARNING

1. The user must comply with all applicable safety laws, rules, and regulations pertaining to the use of this instrument.

2. The standard prescribed by the National Fire Protection Association Code No. 56, Article 248, regarding flammable anesthetics and portable electrical equipment in the anesthetizing location, requires this instrument to be operated at least five feet above the floor with the power cord disconnected. Do not remove or insert the battery pack where the air contains flammable vapors.

3. Whenever power-line operated devices are attached to the OUTPUT connector, this instrument must also be power-line operated **or**, pin 3 of the OUTPUT connector must be connected to an earth ground.

4. Whenever this instrument is power-line operated, be sure to use a grounded, three-wire receptacle.

Fig. 1-1. Type 410 Physiological Monitor

NOTICE

Tektronix, Inc. is not responsible for any consequences arising from:

1. Use of this instrument and/or Tektronix supplied accessories for purpose other than those specified by Tektronix, Inc.

2. Unauthorized modifications.

3. The use of unauthorized replacement parts.

SECTION 1
CHARACTERISTICS

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

The Tektronix Type 410 Physiological Monitor is a portable, battery operated oscilloscope designed for long-term monitoring of ECG, pulse-waveform and EEG. The Type 410 offers simple operation, long time stability and protection against electric shock.

The instrument features solid state circuitry. This means added safety for the patient, as well as long maintenance interval and maximum operating time between battery charges. Other features include triggered sweep on heart related signals, direct heart rate readout and an audible signal at the heart rate. Operational advantages are high common-mode rejection and fast overdrive recovery.

The following instrument characteristics apply over an ambient temperature range of $+10°C$ to $+40°C$ when the instrument has been calibrated in a $+25°C$, $\pm 5°C$ environment, except as noted.

Accessories

An illustrated list of the accessories supplied with the Type 410 is at the end of the Mechanical Parts List pullout pages.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement		Supplemental Information
Bandwidth			
EEG	$\leq$0.1 Hz to 100 Hz, $\pm$15%		
ECG and AUX	$\leq$0.1 Hz to 250 Hz, $\pm$15%		
Calibrated Deflection Sensitivity	Differential Input Voltage		Refer to Differential Volts vs. Gain curve, Fig. 1-2.
	20 mV (DC)	100 mV (DC)	
EEG 10 mm/50 μV	$\pm$5%	0 to $-$10%	
ECG 20 mm/mV	$\pm$5%	0 to $-$10%	
AUX 2 mm/mV	$\pm$5%	0 to $-$10%	
VERTICAL SIZE Range	$\leq$1/3X to $\geq$3X		Where X is the display size with VERTICAL SIZE control in CAL
Differential Dynamic Range	At least 100 mV of either polarity		Refer to Differential Volt vs. Gain Curve, Fig. 1-2.
Common Mode Rejection Ratio (5 V P-P)	60 Hz and 5 kΩ source impedance unbalance	25 Hz to upper B W limit and 0 Ω source impedance unbalance	Contact resistance less than 20 kΩ per electrode
EEG	At least 150,000:1	At least 500,000:1	
ECG (LEAD SELECTOR: I, II or III)	At least 150,000:1	At least 500,000:1	
ECG (LEAD SELECTOR: aV_R, aV_L, aV_F or V)	At least 100,000:1	At least 100,000:1	
AUX	At least 50,000:1	At least 500,000:1	
With 100 mV DC Differential Voltage (EEG or ECG)		At least 150,000:1	
Common Mode Dynamic Range	$+3$ V to -3 V		
Drift	$\leqslant$0.5 centimeters per hour or less after 10-second warmup		
Periodic and Random Deviations	0.1 cm or less (at CAL, on EEG, input shorted)		VERTICAL SIZE in CAL detent, INPUT SELECTOR in EEG, + INPUT shorted to $-$ INPUT
Non-destructive input voltage limits	The instrument need not be disconnected from the patient during cautery or DC defibrillation		
Differential overdrive recovery time	$\leq$4 seconds (for useful vertical information)		
Isolated switch closure	Closed with INPUT SELECTOR at ECG or AUX and open at EEG		Access through the OUTPUT Connector

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Trigger Sensitivity	$\leq$0.5 cm ECG display ($\geq$40 beats per minute) $\leq$0.7 cm pulse display ($\geq$40 pulsations per minute)	
Sweep Free-run delay	2 to 4 seconds after last trigger	
Sweep Speed	25, 50 and 100 mm/s, ±5%	
Battery Check Scale	Green—Normal operation Yellow—Recharge needed, operation not harmful to instrument Red—Do not operate	SWEEP SPEED switch in BATTERY CHECK position
Heart Rate Scale Accuracy	Within ±5% of reading (50 mm/s range, 35 to 110 beats/min).	
Audio	Audio "Beep" at heart rate with alarm activated 2 to 4 s after loss of signal.	
AUDIO OUTPUT Jack	Mating plug cuts off internal speaker	
Battery Pack	Ten size "C" NiCd cells; 1.8 Ah rechargeable by charger within pack.	
Charging Time	14 to 16 hours	
Discharge Time (for 016-0107-00 and 01)	8 to 12 hours operation with maximum accessory load at +20°C to +25°C	
Discharge Time For 016-0107-02, All models	6 hours of operation with full accessory load when display baseline stays within 3 divisions of graticule center, increasing to 8 hours in ECG or EEG with baseline kept within 1 division of graticule center. Time decreases above 25°C.	
Battery Operating Range	11.9 V to 15.0 V	
AC Input Power	$\leq$7 W at 115 V, 60 Hz	
Line Voltage	90 V to 136 V AC 180 V to 272 V AC	
Line Frequency	48 to 440 Hz	
Turn-on Time	$\leq$4 s	
CRT Type	5 inch (Type 154-0508-00 with P7 phosphor)	

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information
Temperature		
Non-operating	−40°C to +60°C	
Operating	+10°C to +40°C	
Altitude		
Non-operating	to 50,000 feet	
Operating	to 10,000 feet	
Dimensions	5$^3/_8$ inches × 8$^1/_2$ inches × 10$^3/_4$ inches (without handle length or width). 5$^3/_8$ inches × 9$^1/_8$ inches × 12$^3/_8$ inches (with handle horizontal).	
Weight	≈12$^1/_2$ pounds with battery pack, without accessories.	

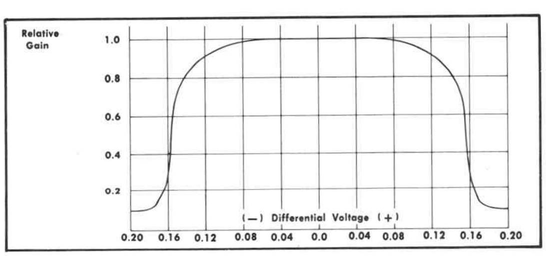


Fig. 1-2. Differential voltage vs. gain

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

Instrument Description

The Type 410 Physiological Monitor can be a valuable diagnostic tool, but its primary use will probably be in long-term EEG, ECG and pulse monitoring, particularly in surgery, recovery and intensive care. Pulse monitoring is accomplished with the optional pulse sensor.

The Type 410 features battery or line operation, large viewing screen in a portable package and good electrical interference rejection. Other special advantages are cool operation, light weight, easy cleaning, a variety of mounting methods, simplicity of controls and protection against electrical shock.

CONTROL FUNCTIONS

SWEEP SPEED Selector

A 5 position switch (see Fig. 2-1) for selecting any of the following:

POWER OFF: Power is removed from the terminals of the Patient Cable as well as from the internal circuitry. Moving away from the POWER OFF position (to any of the other 4 positions) applies power to the internal circuitry and to the auxiliary power terminals of the Patient Cable, when the INPUT SELECTOR is in the AUX position.

With the instrument power cord connected to the AC power battery charging continues with the SWEEP SPEED selector in POWER OFF.

25 mm/s: The spot traces horizontally across the viewing area at 25 millimeters per second. This gives the same horizontal spacing between QRS complexes as one of the chart speeds commonly found on ECG strip chart recorders.

50 mm/s: The spot traces horizontally across the viewing area at 50 millimeters per second. This gives the same horizontal spacing between QRS complexes as another of the chart speeds commonly found on ECG strip chart recorders. This sweep speed is used with the Heart Rate Scale discussed later in this section under Graticule Scales.

Fig. 2-1. Location of SWEEP SPEED and INPUT SELECTOR controls.

100 mm/s: The spot traces horizontally across the viewing area at 100 millimeters per second.

BATTERY CHECK: Used in conjunction with the Battery Check Scale (the red-yellow-green scale along the bottom edge of the viewing area). This color scale indicates battery voltage that is related to battery state of charge. See Graticule Scales later in this section.

INPUT SELECTOR

A 3 position switch, shown in Fig. 2-1, for selecting functions and input sensitivity. See Table 2-1. The function in each position is as follows:

EEG: Used to monitor electrical activity of the brain or other low-level signals such as fetal ECG.

ECG: Used to monitor the electrical activity of the heart. The calibrated sensitivity produces twice the display amplitude of conventional ECG strip chart recorders.

AUX: Used in conjunction with a transducer for measurements such as pulse monitoring.

TABLE 2-1

Switch Position	Sensitivity	Aux Pwr	Switch[1] Contacts	Triggered Sweep
EEG	10 mm/50 μV (50 μV/cm)	No	Open	No
ECG	20 mm/mV (0.5 mV/cm)	No	Closed	Yes
AUX	2 mm/mV (5 mV/cm)	Yes	Closed	Yes

[1]**See CONNECTOR FUNCTIONS; OUTPUT Connector.**

VERTICAL SIZE

The VERTICAL SIZE control, when in the CAL (calibrated detent) position near midrange, produces a display scale factor as indicated by the INPUT SELECTOR switch (for example, ECG—20 mm/mV). Counterclockwise rotation of the VERTICAL SIZE control from CAL position decreases display size by a factor of at least 3 (divides the display amplitude by 3). Clockwise rotation from CAL increases display size by a factor of at least 3. See the Characteristics section, for accuracy.

VERTICAL POSITION

The VERTICAL POSITION control is comparable to the "centering" control found on many electrocardiographs and permits the display and baseline to be positioned vertically as desired. The baseline should be centered when the control is near midrange. The trace may not position off screen due to the scan limiting circuitry in the vertical amplifier.

ECG LEAD SELECTOR

The ECG LEAD SELECTOR selects any one of the standard lead configuration most commonly used in cardiography: I, II, III, aV_R, aV_L, aV_F, and V. To measure all seven lead configurations without moving electrodes, five properly placed electrodes are necessary. See Electrode Placement later in this section.

LOUDNESS

The LOUDNESS control sets the sound level of the audible signal, a gated tone produced in either the built-in speaker or an earphone when plugged into the AUDIO OUT jack.

Line Voltage Range

The Line Voltage Range switch is the two position slide-type switch recessed into the front of the battery pack. This slide switch selects either 115 or 230 volt line operation. See Fig. 2-2. The range of operating voltage is given in Section 1.

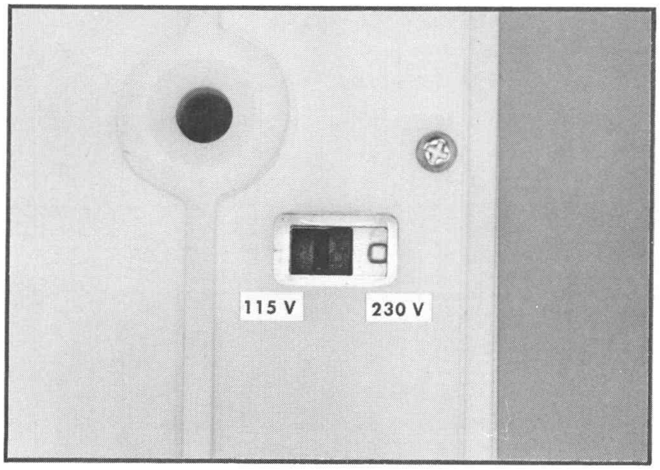


Fig. 2-2. Location of Line-Range switch.

CONNECTOR FUNCTIONS

PATIENT CABLE Input

The PATIENT CABLE Input is a 12-pin connector mounted at the top of the rear panel. This connector mates with the 12-pin connector on the Patient Cable. See Fig. 2-6.

The shell of the 12-pin Patient Cable connector must make no electrical contact with anything other than the shell of the 12-pin connector on the rear of the instrument. This shell is not and should never be tied to any ground, external or otherwise, since this would prevent part of the interference eliminating circuitry from operating properly.

Patient Cable Terminating Block

The Patient Cable Terminating Block is the connecting block on the patient cable to which the electrodes and transducers are connected. See Fig. 2-3. Features and use are discussed later in this section.

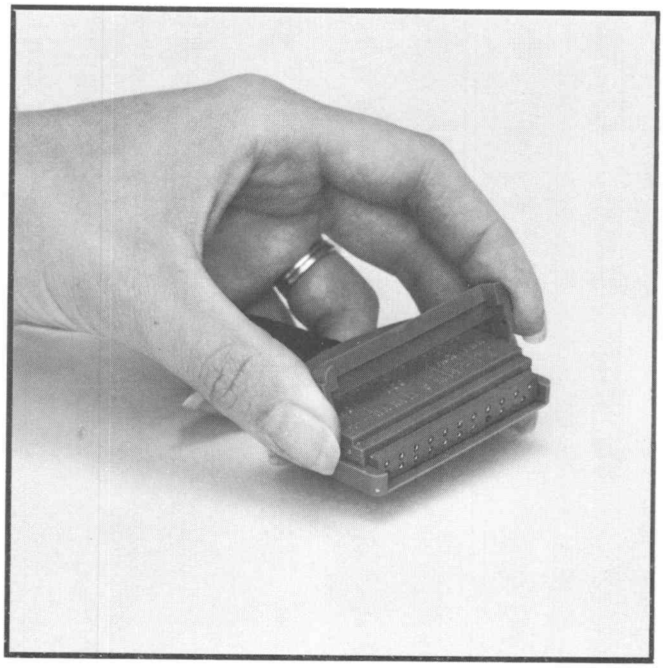


Fig. 2-3. Patient Cable Terminating block.

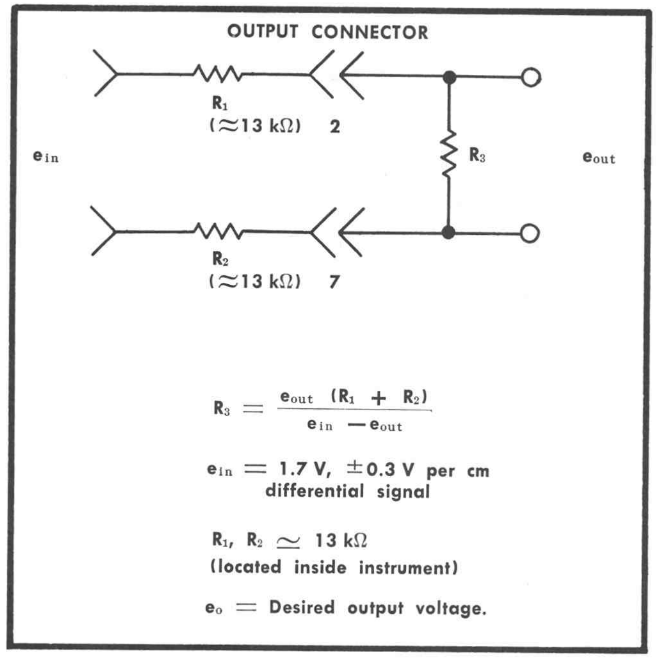


Fig. 2-4. Suggested loading resistor to reduce output signal amplitude.

OUTPUT Connector

The OUTPUT connector is a 7-pin connector (Fig. 2-6) located on the rear panel, at the bottom directly beneath the PATIENT CABLE INPUT connector. A 7-pin plug, Tektronix Part Number 131-0551-00, is available for connecting external equipment to the Type 410 OUTPUT connector.

The OUTPUT connector provides the differential vertical signal for operation of external recording or indicating devices; strip-chart recorders, slave oscilloscopes, etc. Upward deflection on the CRT results in a positive-going voltage on pin 2 and a negative-going voltage on pin 7. Reverse deflection produces opposite polarities. The + and — signal level is 1.7 (±0.3) volts differential per division of display. If this signal amplitude is too great for the external device, a loading resistor may be used to reduce the amplitude. See Fig. 2-4.

Due to variations from one Type 410 to another, do not expect better than 20% accuracy from attenuators calculated in Fig. 2-4.

Table 2-2 lists several useful attenuator values.

Very accurate output voltages may be received using the circuit shown in Fig. 2-5.

TABLE 2-2

Output/displayed cm	Calculated value	Use
0.5 mV	7.5 Ω	(2) 15 Ω paralleled
10 mV	150 Ω	150 Ω
100 mV	1.6 kΩ	1.6 kΩ
1.0 V	36.3 kΩ	36 kΩ

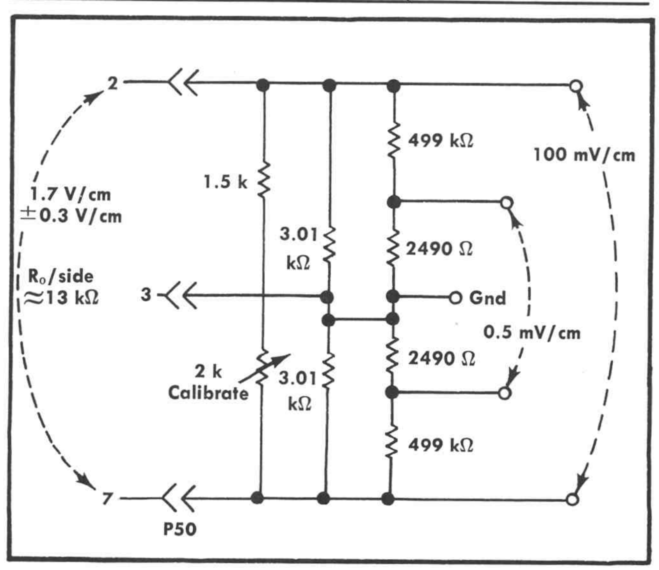


Fig. 2-5. General form of a recommended output attenuator.

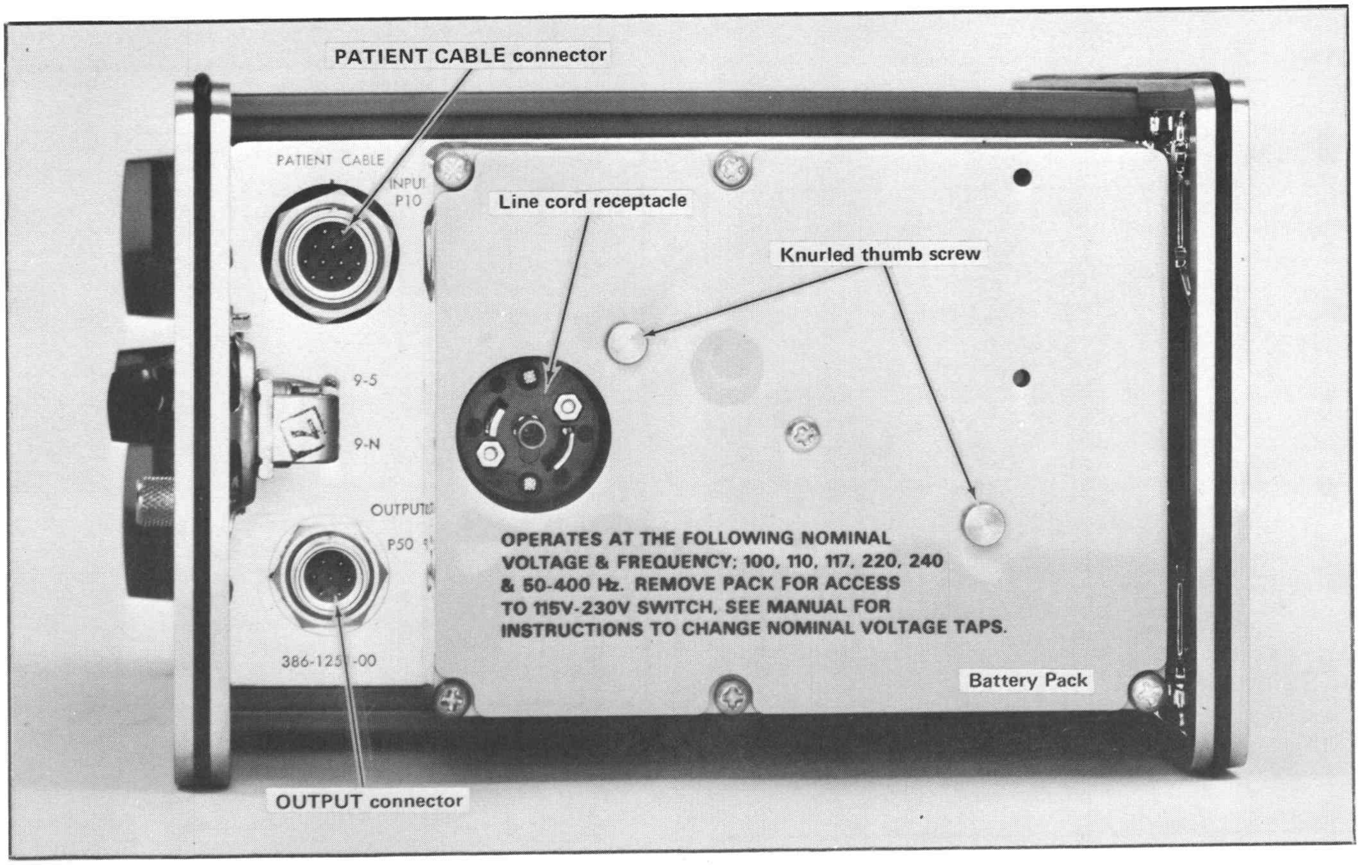


Fig. 2-6. Rear view of the Type 410 with cover removed.

A trigger is provided on pin 4 of the OUTPUT connector for use with a remote or slave oscilloscope. Complete the circuit to ground, pin 3.

The switch contacts listed in Table 2-1 are electrically isolated from all other internal circuits and are accessible via pins 5 and 6 of the OUTPUT connector. This switch logic can be used to enable or disable external devices that use the vertical and trigger output signals from the Type 410 This permits, for example, separation of cardiac related signals from non-cardiac related signals.

The current and voltage applied to the isolated switch contacts should be limited as follows:

100 mA maximum at 12 VDC, resistance load.

150 VDC maximum between switch contacts and the Type 410 circuit ground. Use DC only, to avoid interference with other circuits.

AUDIO OUT Jack

The AUDIO OUT Jack provides a means of monitoring the gated tone with an earphone or remote high impedance speaker. The earphone plug, when inserted into the jack, cuts off the built-in speaker. The LOUDNESS control sets the sound level to the earphone (or speaker). The miniature phone plug is available from Tektronix Inc. (Tektronix Part Number 134-0079-00) or may be purchased from most radio and TV parts suppliers (for example, Switchcraft® Part Number 850).

CASE GROUND

CASE GROUND provides a means of connecting the case to the electrical system ground. See Fig. 2-1. Also see the paragraph on grounding later in this section.

Line Cord Receptacle

The Line Cord Receptacle is the three-terminal receptacle recessed into the rear of the battery pack which provides a means of connecting the battery pack charger to a 115 or 230 volt power line. See Fig. 2-6.

GRATICULE SCALES

Battery Check

The Battery Check Scale is the 3 color band across the bottom of the viewing area. The scale indicates battery voltage which is related to battery state of charge. See Fig. 2-7. Switching the SWEEP SPEED Selector to the BATTERY CHECK position changes the function of the horizontal axis from sweep to expanded-scale, slideback voltmeter. Vertical information continues to be seen as vertical motion of the spot. The horizontal position of the display (spot) indicates

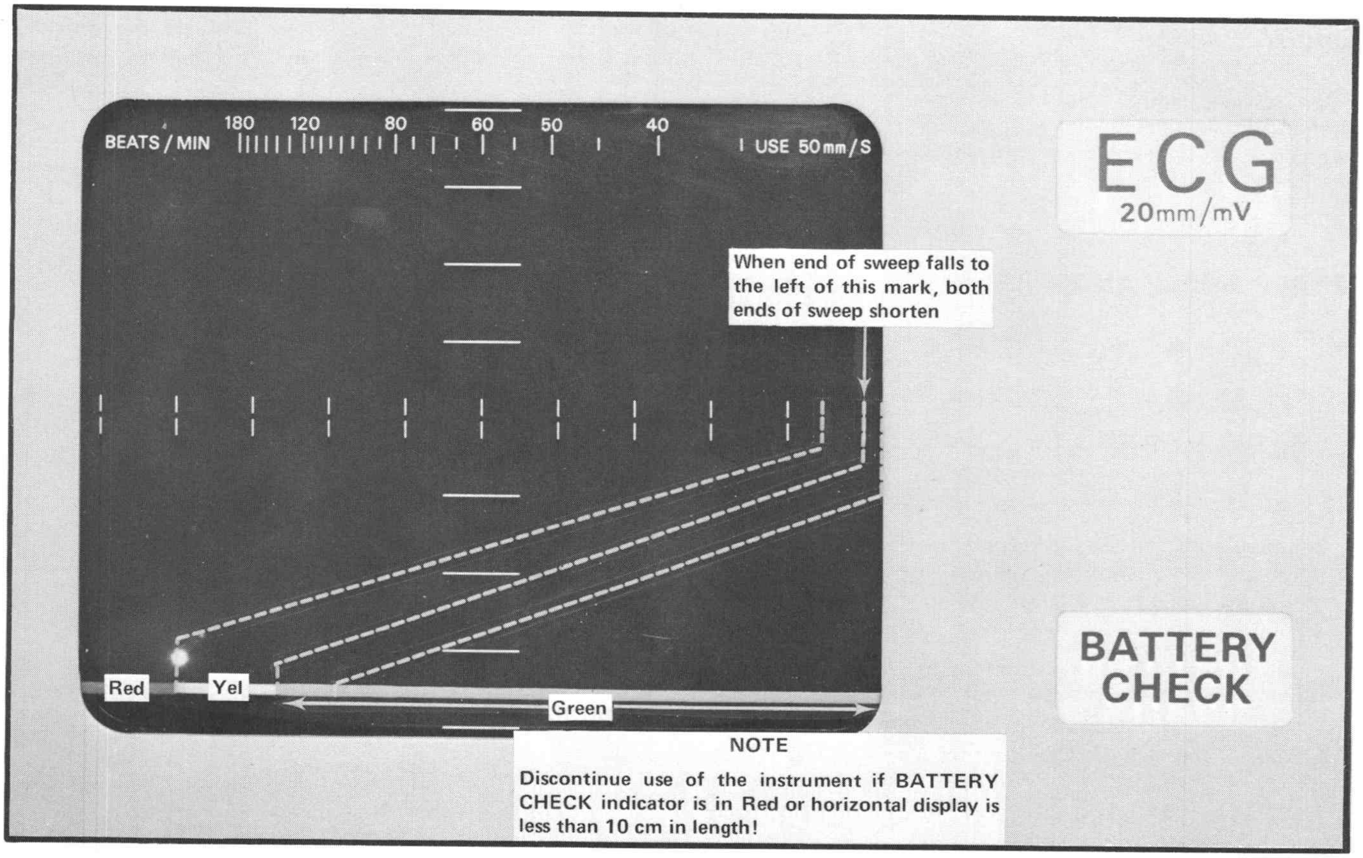


Fig. 2-7. Battery Check scale.

battery voltage. The farther to the left the spot is positioned, the lower the state of charge.

The battery, when fully charged, will initially indicate off-screen to the right. The spot will return on-screen a few minutes after removing the charge.

Do not use the instrument on batteries if the horizontal display, or normal sweep has shortened to less than 10 centimeters in length. Also see the NiCd discussion later in this section.

If no spot is visible, switch the SWEEP SPEED selector to 100/mms and check the sweep length. If the sweep is 10 cm or more in length, the battery is fully charged.

There is some possibility that an instrument using the 016-0170-02, Model 4 Power Pack will temporarily switch back to BATT mode within a few minutes after it has automatically switched from BATT mode. While this will cause no harm to either battery or instrument, the SWEEP SPEED switch should be turned to the POWER OFF position until the battery can be recharged.

Heart Rate Scale

The Heart Rate Scale across the top of the graticule provides direct indication of heart rate in beats per minute. Incorporation of this scale is made possible by two factors; triggered sweeps and calibrated sweep speeds.

Triggered sweeps are obtained with two of the three settings provide on the INPUT SELECTOR switch; ECG and AUX. Therefore, fetal ECG monitoring (using the EEG inputs for the required sensitivity) will not permit use of the Heart Rate Scale because the EEG setting produces a self-triggered or free-running sweep.

The scale is primarily for use with a 50 mm/second sweep speed; therefore, the numbers on the scale apply only when that sweep speed is used. For heart rates above 30 beats per minute, there will always be two or more QRS-complex waveforms (or other heart related waveforms) on the screen. The first will appear at a fixed position at the left-hand edge due to sweep triggering. The second will be some distance to the right of the first, determined by the time interval between heart beats, and the sweep speed. Since the sweep speed is known and the distance to the second beat can be measured, heart rate can be calculated. The scale reflects this calculation.

Note that there is a two to one relationship between the 100 mm/s and 50 mm/s sweep speeds. Because of this simple relationship, heart rates read from the scale with a 100 mm/s sweep speed can be multipled by two to obtain the correct rate. By the same reasoning the 25 mm/s sweep rate requires division by two. Greatest accuracy is obtained using the 50 mm/s sweep speed.

Horizontal Axis

The Horizontal marks at the centerline are in centimeters and are a means of relating the horizontal distances to time. For example, 5 cm between pulses on the 50 mm/s scale is equal to 1 second.

Vertical Axis

The vertical marks are in centimeters, which simplifies relating display amplitude to input signal voltage. For example, a 5 centimeter peak to peak display at 20 mm/mV is equal to 2.5 millivolts.

PREPARATION AND FIRST-TIME OPERATION

Upon receipt of your new Type 410 Physiological Monitor, it will be necessary to carry out the following procedure:

1. Set the SWEEP-SPEED switch to POWER OFF.

NOTE

When the instrument is shipped, Line-Range switch is set at 115 volts, as indicated on the tag attached to the instrument. If you wish to change the switch position, proceed as follows:

2. Remove the rear 'pop' cover as shown in Fig. 2-8.

3. Remove the battery pack as shown in Fig. 2-9.

4. Set the Line-Range switch, (slide-type switch recessed in the front of the battery pack) Fig. 2-2, to the appropriate line voltage range, 115 or 230 volts. In most cases the line-frequency is 50 or 60 Hz. However, as noted in Section 1, the instrument will operate at all line frequencies from 48 to 440 Hz without modification or control changes.

5. Re-install the battery pack as follows:

Align the two 1/4 inch diameter rods extending outward from the rear panel with the guide holes in the battery pack, being sure to position the pack so that the three banana plugs on the rear panel are in line with the banana jacks on the battery pack. Slide the battery pack into place and push the pack against the rear panel. See Fig. 2-10. Tighten the two knurled thumb screws.

6. Set the SWEEP SPEED control to BATTERY CHECK. The battery should be in a proper state of charge, as indicated by the display of a spot on the cathode ray tube above the green color stripe. If for any reason the battery is not sufficiently charged, the displayed spot may appear above the yellow or red color stripes, or be absent entirely. If such is the case, refer to Battery Charging Instructions later in this section. If the battery indicates a proper state of charge, proceed to Step 7.

7. Connect the Patient Cable by positioning the color stripe on the Patient Cable plug to the keyway on top of the receptacle. Push the plug firmly into the receptacle. The plug will lock (color ring will show when locked) into the receptacle and may be removed only by pulling on the lanyard connected to the plug. The plug cannot be removed by pulling on the Patient Cable. See Fig. 2-11. Connection and removal will normally be done with the cover in place.

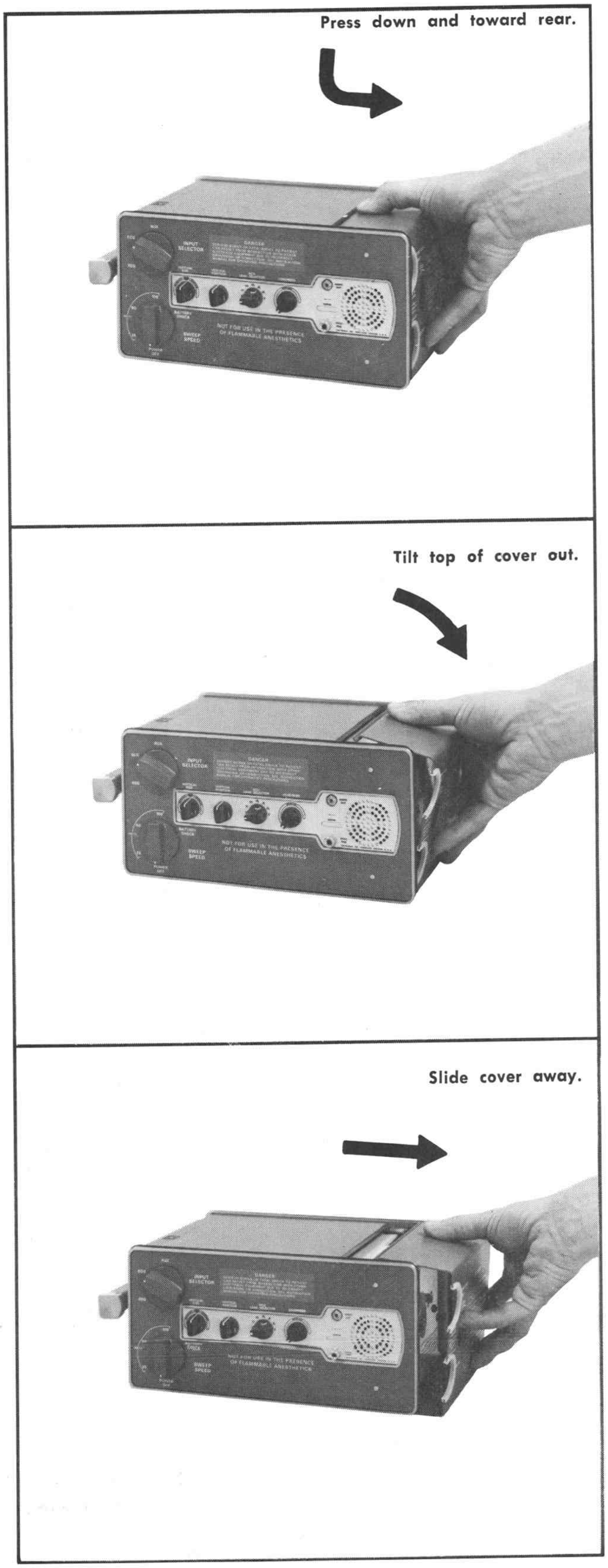


Fig. 2-8. Removing rear cover.

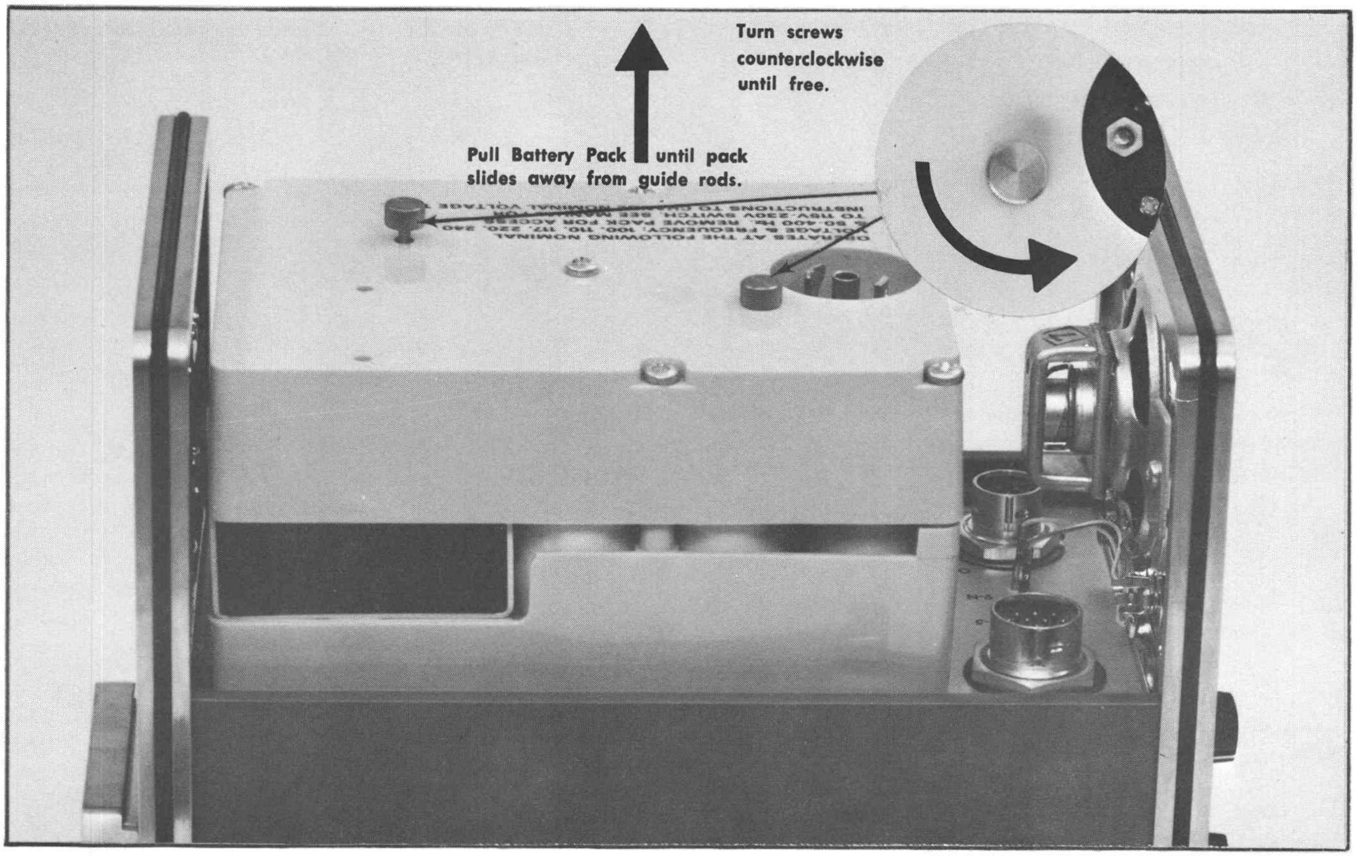


Fig. 2-9. Removing the Battery Pack.

NOTE

The Patient Cable connector is recessed in the rear of the instrument to prevent accidental short circuit of the guard voltage which is present on the metal shell, and to avoid physical damage to the connector assembly.

8. Re-install the rear cover.

9. Set the controls on the side panel as follows:

INPUT SELECTOR	EEG
SWEEP SPEED	POWER OFF

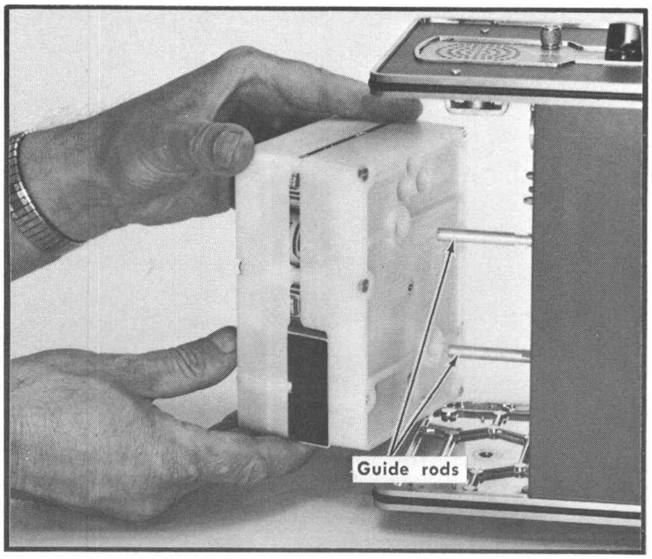


Fig. 2-10. Installing the Battery Pack.

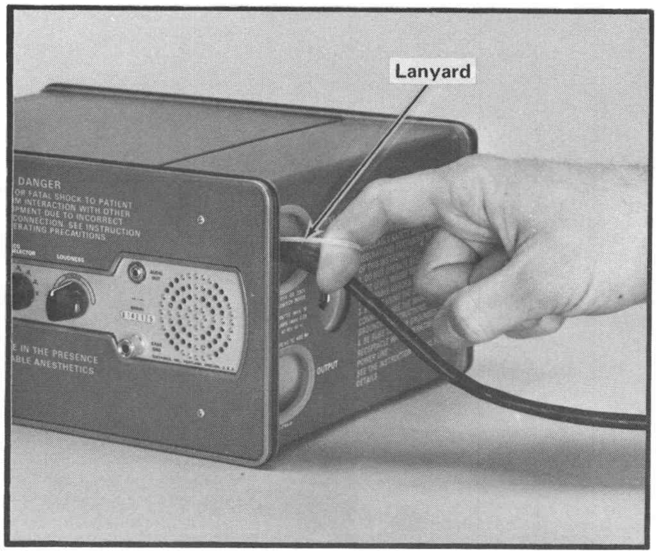


Fig. 2-11. Removing Patient Cable.

VERTICAL SIZE	CAL (midrange detent)
VERTICAL POSITION	Middle of the range
ECG LEAD SELECTOR	I
AUDIO LOUDNESS	min

10. Turn the SWEEP SPEED switch from POWER OFF position to 25 mm/s position. Within approximately 5 seconds, a spot should appear in the viewing area and move to the right. The spot should disappear at the right edge of the viewing area and re-appear at the left side, repeating the movement to the right. The spot may move rapidly back and forth a small amount vertically due to lack of connection to a patient.

Each sweep of the spot horizontally across the viewing area should take approximately 4 seconds, using the 25 mm/s sweep speed. The trace should be approximately centered vertically in the viewing area. Rotate the VERTICAL POSITION control and note that the spot can be moved to the top or bottom of the viewing area. (It may not be possible to position the spot out of the graticule area because of the scan limiting clamps in the vertical circuitry). Return the trace to the center of the screen.

11. Switch the SWEEP SPEED control to 50 mm/s (HEART RATE SCALE) and note the speed with which the spot moves across the viewing area. The duration of one sweep should be approximately 2 seconds. Switch the SWEEP SPEED control to 100 mm/s and note that the time for one sweep is now approximately 1 second.

12. Switch the INPUT SELECTOR to ECG. Note that the sweep speed does not change. Turn the LOUDNESS control clockwise until an interrupted tone is heard from the speaker. Switch the INPUT SELECTOR to EEG and back to ECG. As soon as the sweep starts again, the interrupted tone should again be heard. This waiting period, 2 to 4 seconds, allows the instrument to seek a sweep triggering signal. If no suitable signal occurs during the interval, the sweep will start itself and the audio tone will turn on and off rapidly to serve as an alarm. Note that during the waiting period, the spot is visible at the left side of the screen and any vertical motion is easily recognized.

13. If one is available, plug an earphone having an impedance equal to or greater than 100 ohms into the AUDIO OUT jack. Note that the tone is now heard in the earphone and not from the built-in speaker.

14. Switch the INPUT SELECTOR control to AUX. After a delay of 2 to 4 seconds the tone should again be heard. If the INPUT SELECTOR is switched at midsweep at any sweep speed the tone should cease, but the sweep then in progress will proceed to completion. After a 2 to 4 second waiting period, the tone should again be heard and the sweep will restart.

15. Rotate the SWEEP SPEED control to BATTERY CHECK. The spot position should remain unchanged vertically. The horizontal spot position relative to the three color band indicates the battery voltage, which is related to charge condition. If the spot is not located above the green area of the Battery Check Scale the battery should be charged. Refer to the GRATICULE SCALES and Charging Instructions earlier in this section. Reset the SWEEP SPEED switch to 50 mm/s.

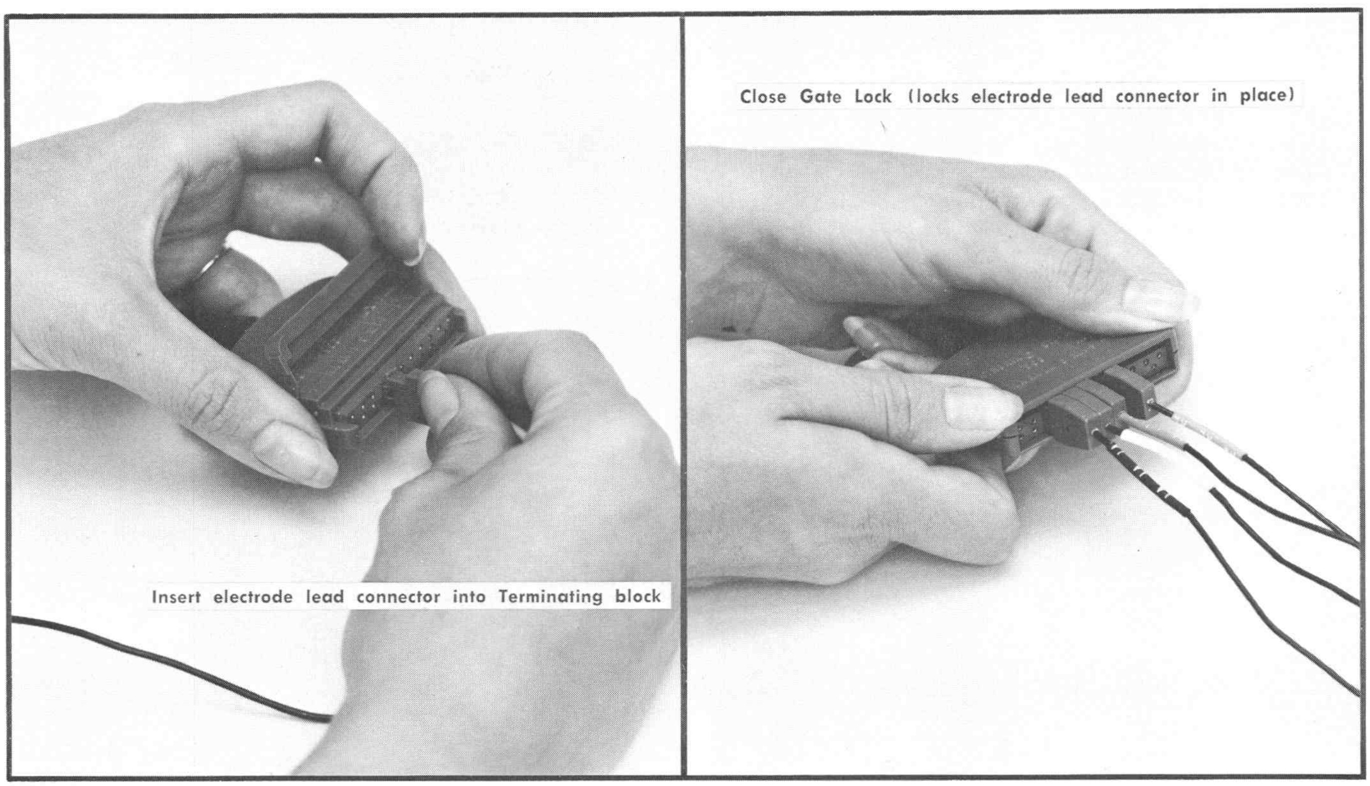


Fig. 2-12. Patient Cable Terminating Block and method of locking electrode connectors in place.

16. Connect an electrode to each arm, white (RA) to the right arm, black (LA) to the left arm and green (RL) to the right leg as shown in the Application instruction later in this section.

17. Connect the three leads to the Patient Cable terminating block. Fig. 2-12 shows the Patient Cable, terminating block and method of locking the electrode cable connectors to the terminating block. Further information on Patient Cable and terminating block follows the electrode placement chart later in this section.

18. Connect the white lead to the RA (abbreviation for right arm) terminal, black to LA (left arm) and green to RL (right leg).

19. Switch the INPUT SELECTOR to ECG. The ECG LEAD SELECTOR remains on I.

20. Relax completely, preferably reclining, and watch the viewing area for a display similar to that of Fig. 2-13.

At 50 mm/s two or more QRS complexes will be seen on the viewing area. Since the sweep is triggered on some point on the first QRS complex, the same point on the second QRS complex will indicate the heart beat rate. For more information on the Heart Rate Scale, refer to GRATICULE SCALES earlier in this section.

NOTE

Do not use a VERTICAL SIZE setting which will allow any peak of the display to be off-screen.

BATTERY CHARGING INSTRUCTIONS

1. Set the SWEEP SPEED switch to POWER OFF.

2. Connect the power cord to the power outlet and to the Battery Pack as shown in Fig. 2-14.

3. Leave the power cord connected to the battery for 14 to 16 hours.

4. Disconnect the power cord. The battery is fully charged and ready for use.

The Type 410 can be operated continuously with the power cord attached. The charge delivered to the battery in this mode of operation will keep the battery fully charged without causing any cell damage.

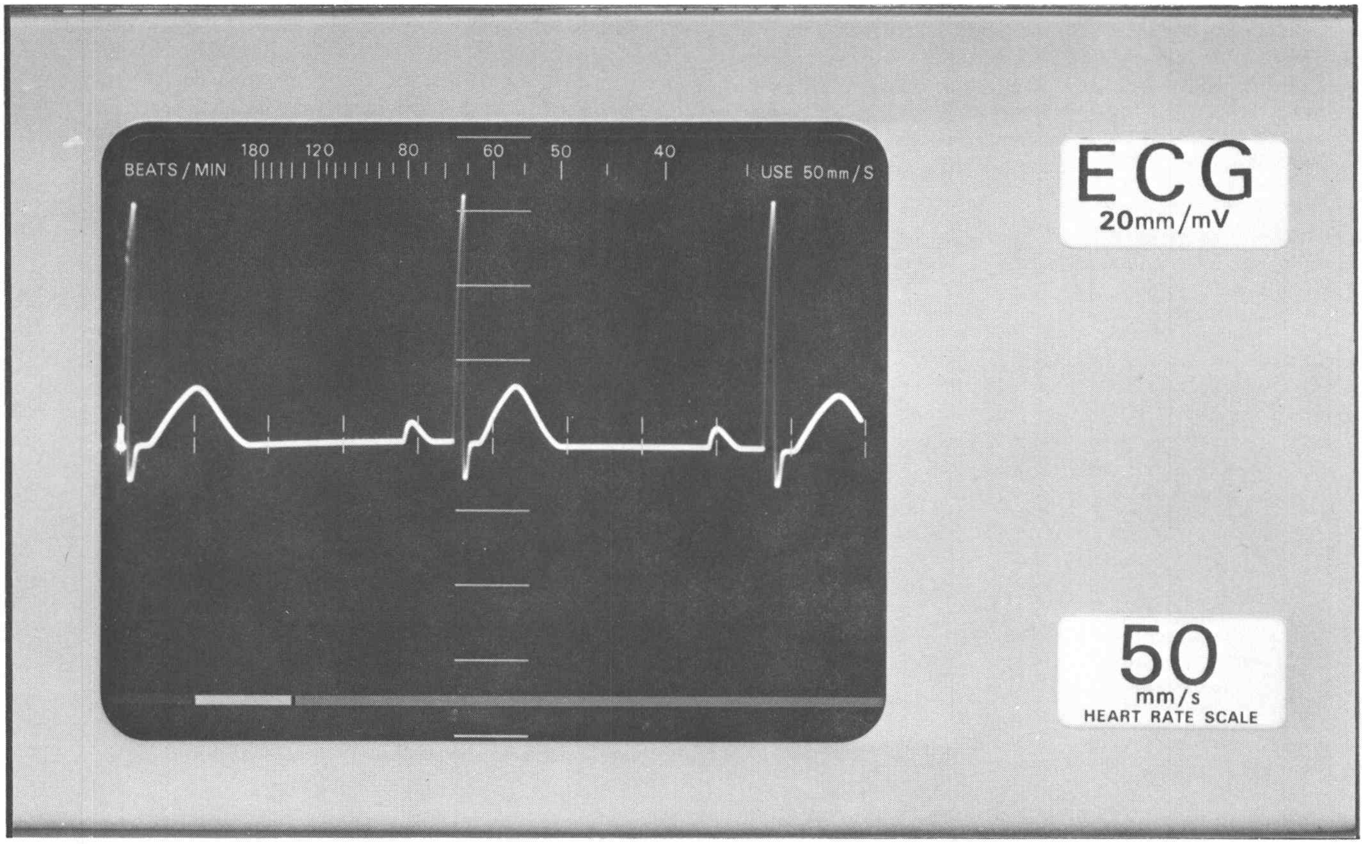


Fig. 2-13. Typical display showing use of the Heart Rate scale.

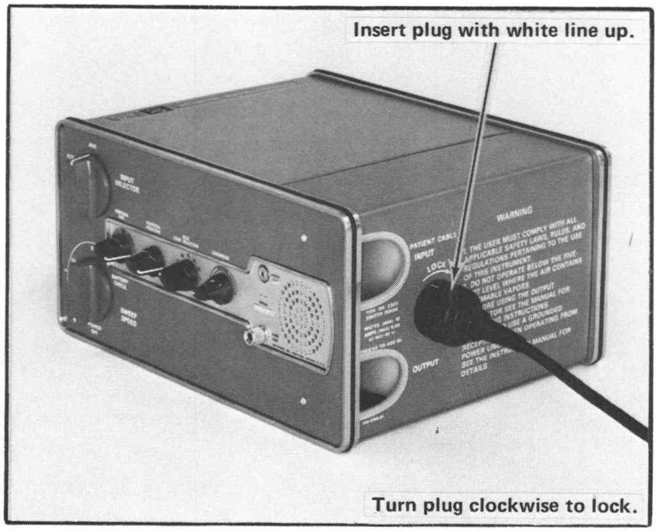


Fig. 2-14. Connecting the Power Cord to the Type 410.

While repeated partial recharging can lead to a substantial state-of-charge imbalance between cells (due to slight differences in ampere-hour capacity) a partial recharge can be worthwhile since thirty to forty-five minutes of running time will be added for each hour of charging time. State-of-charge balance will be restored by a full 14 to 16-hour charge.

If the instrument is used intermittently, charge the cells during the idle periods. At the first opportunity, recharge the cells for 14 to 16 hours.

An example of the most desirable use-charge sequence might be as follows: If the instrument is used for 4 hours today and will be used two hours tomorrow, it is better to charge the cells today instead of waiting until after tomorrow's use. Let the cells charge overnight. No harm will be done if the cells are left charging many hours more than required to restore full charge.

NOTE

The cells supplied with the Type 410 are rated at 1.8 ampere-hours, minimum. At this rating, 14 to 16 hours of charging time is adequate. However, many cells exhibit higher ampere-hour capacities and require greater charging times (20 to 24 hours).

Cells exhibit highest ampere-hour capacities when new.

ELECTRODES

The Type 410 is designed for high common mode rejection and quick recovery, and therefore has no input coupling capacitors. Without input capacitors the instrument can tolerate only small DC voltages (offsets) between the electrodes. Offset is also undersirable because of motion artifacts.

Offsets are due to:

1. Polarization of similar metal electrodes. Due to passage of DC current between electrodes which causes dissimilar chemical changes between the two electrodes. As a result of these chemical differences, an offset may exist after the external source of current is eliminated.

Electrodes such as silver-silver chloride (Ag/AgCl) supplied with the Type 410 are difficult to polarize because an integral part of each electrode is a surplus of the polarization product chemical. A current from an external source for a short period of time will not significantly alter this balance.

2. Contamination of electrode surfaces unequally or with different chemical substances.

3. Galvanic or battery action of dissimilar metals. Body fluids or electrode pastes act as the electrolyte and no charging current is required to develop a difference of potential.

Ag/AgCl electrodes are similar metals with carefully controlled purity levels as well as controlled proportions of silver and silver chloride, so they are not subject to galvanic action.

In addition to providing consistently predictable results due to absence of offset, the Ag/AgCl electrodes are desirable because they are spaced away from the flesh, giving typically less motion artifact than direct contact types. Their small size affords the wearer maximum comfort, particularly in the intensive care environment. The electrode leads are shielded to minimize electrostatic interference. Low contact impedance helps to insure high common-mode rejection. When used with adhesive rings, electrode paste evaporation is held to a minimum.

Electrode Preparation and Application

Prepare the electrodes furnished with the Type 410 as follows: Be sure that the electrode metallic surface is clean. See the later section on Electrode Cleaning. Use the procedure shown in Fig. 2-15. Remove an adhesive ring from the strip and place the ring upon the electrode. Fill the cup slightly more than level full with the conducting paste, remove the paper backing on the adhesive ring and center the exposed adhesive over the reddened area. Press into good contact with the skin. Tape the lead to the skin about 4 inches from the electrode to relieve undue strain on the electrode.

The silver-silver chloride electrodes supplied with the instrument may be held in place with other than the double-sided adhesive rings. See Figures 2-16 and 2-17.

Use of Electrode Types other than Ag/AgCl

It is possible to make use of other types of electrodes than those supplied with the Type 410 by taking the following precautions:

Use similar materials. For example, all of the electrodes used might be silver plated. In the case of disposable foil or needle electrodes, the best assurance of similarity will be gained by using one brand of consistent part numbers and, if possible, all from the same production period to guard

against accumulated minor metallurgical changes over weeks or months of production.

Re-usable electrodes, such as silver, may require special precaution. Tarnish on one or more electrodes may produce undesirable offset potentials. To avoid offsets of this type, use electrodes having the same degree of tarnish or thoroughly clean the electrode before use.

Silver electrodes may become polarized in previous use. Polarization remains with the electrodes.

Figures 2-18, 2-19 and 2-20 show preparation and application of disposable, plate and needle electrode types.

Adapting electrodes to the Type 410 Patient Cable terminating block is shown in Fig. 2-21.

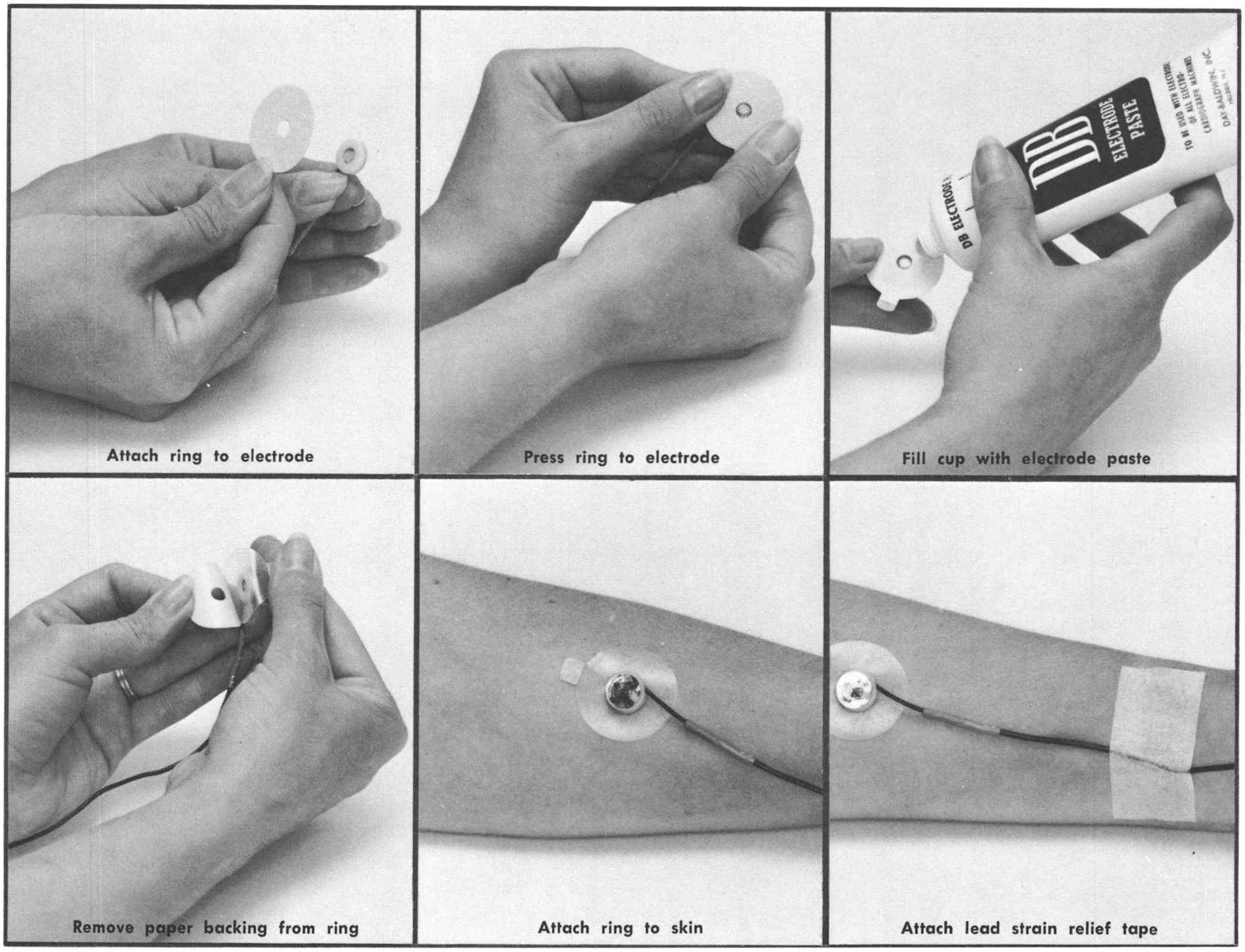
Electrode Color Codes

The Type 410 electrodes are color coded as shown in Table 2-3.

TABLE 2-3

Electrode	Color
RA	White
LA	Black
RL	Green
LL	Red
C^2	Brown
EEG^2	Yellow

[2]**Optional accessories**



Attach ring to electrode — Press ring to electrode — Fill cup with electrode paste — Remove paper backing from ring — Attach ring to skin — Attach lead strain relief tape

Fig. 2-15. Preparation and application of Ag/AgCl electrode, secured to skin with adhesive ring.

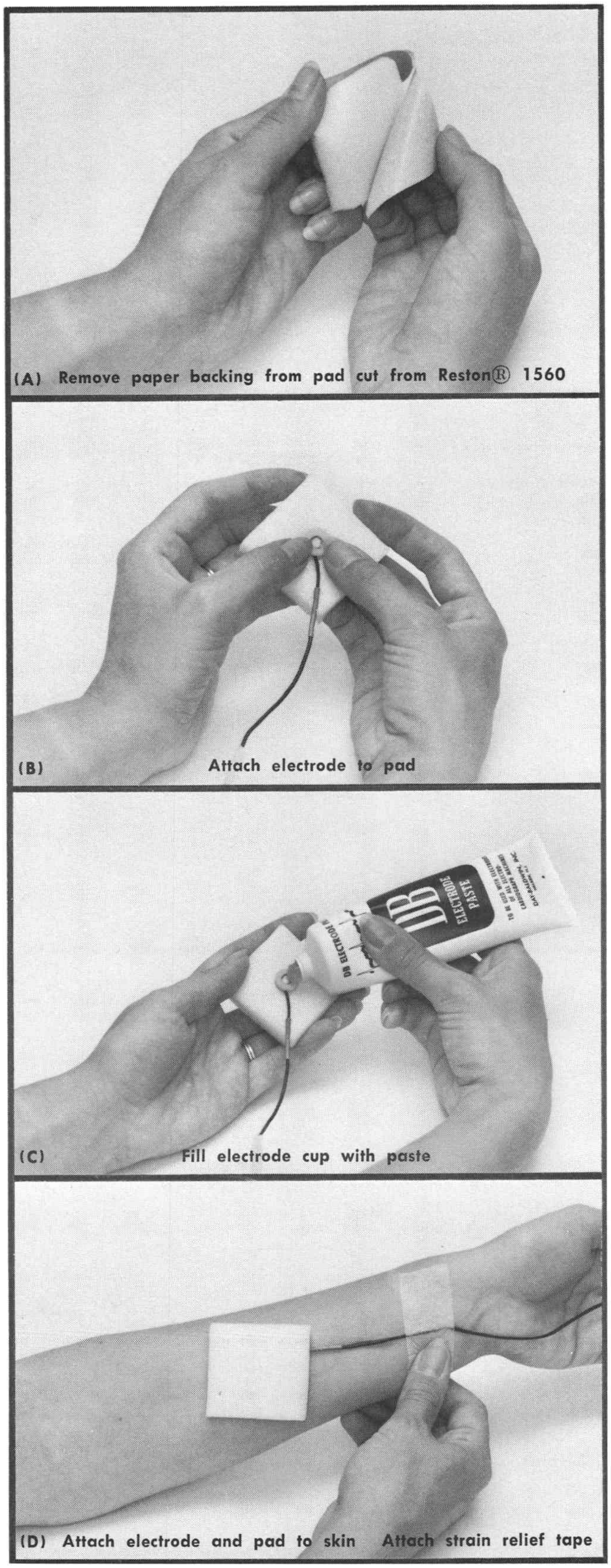


Fig. 2-16. Prepartion and application of Ag/AgCl electrodes secured to skin with adhesive sponge pad.

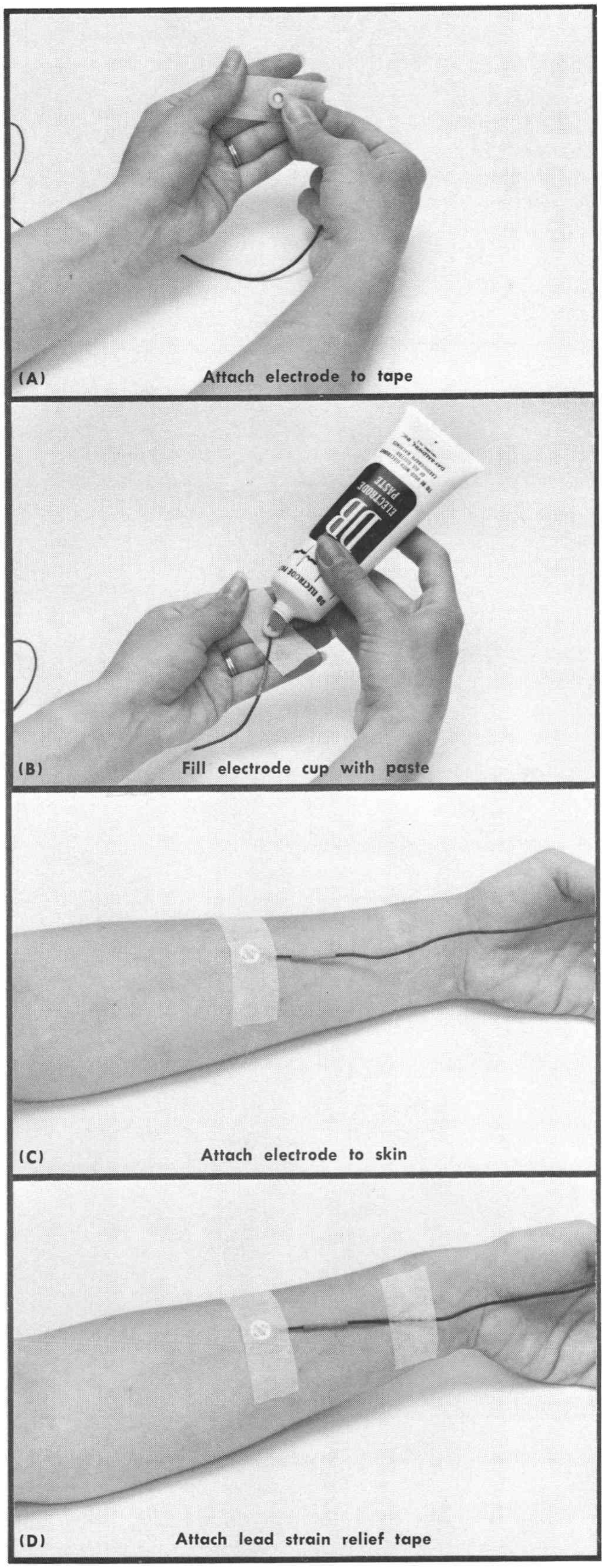


Fig. 2-17. Preparation and application of Ag/AgCl electrode secured to skin with tape.

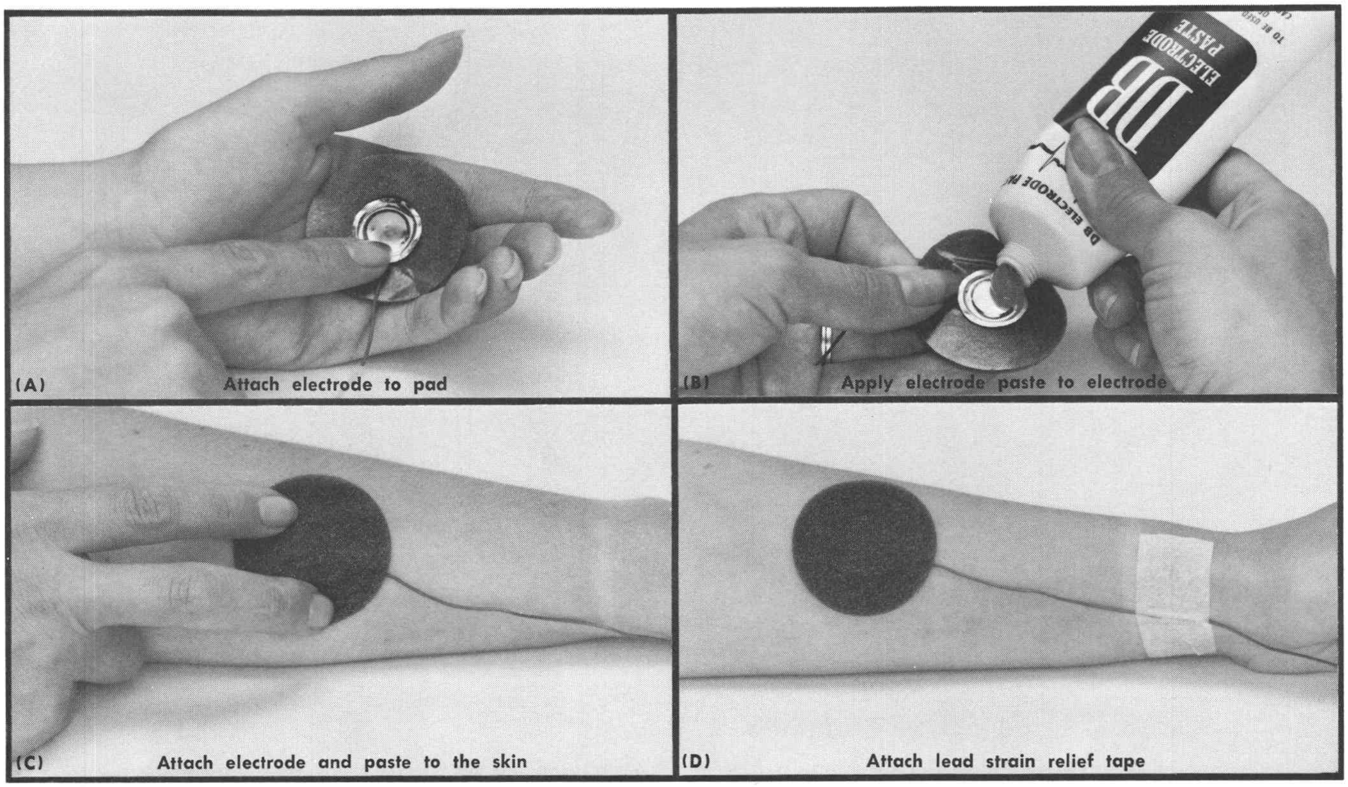


Fig. 2-18. Preparation and application of disposable Ag electrode.

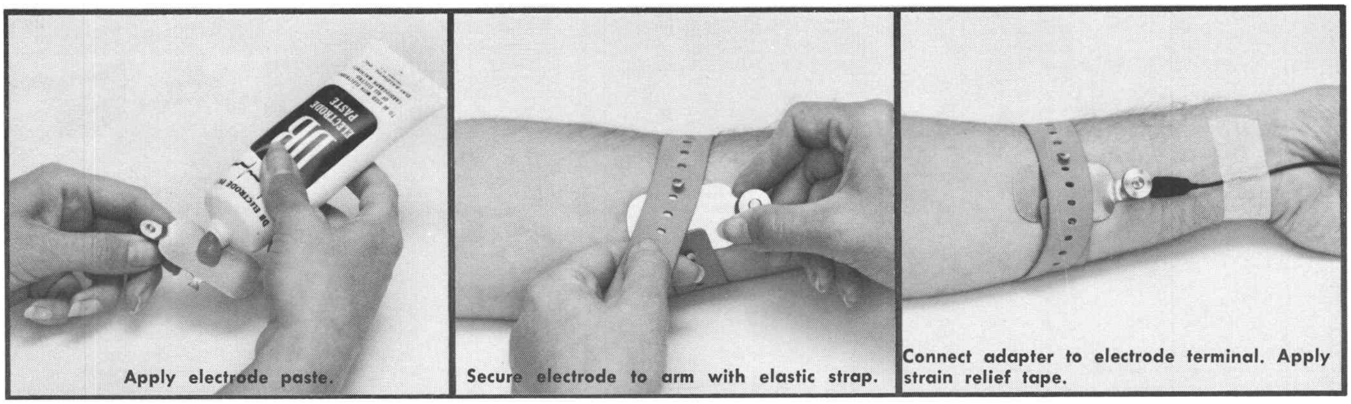


Fig. 2-19. Preparation and application of plate electrode.

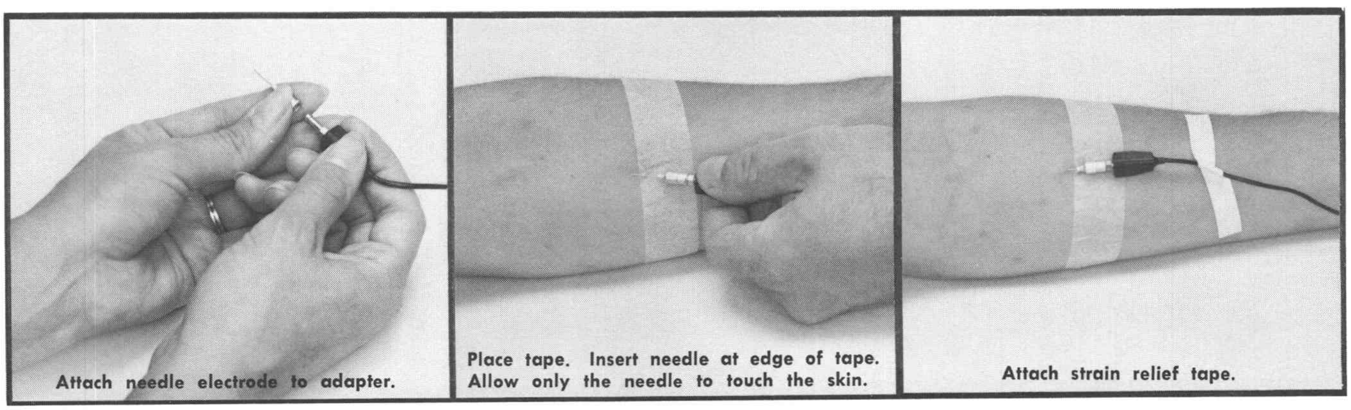


Fig. 2-20. Preparation and application of needle electrode.

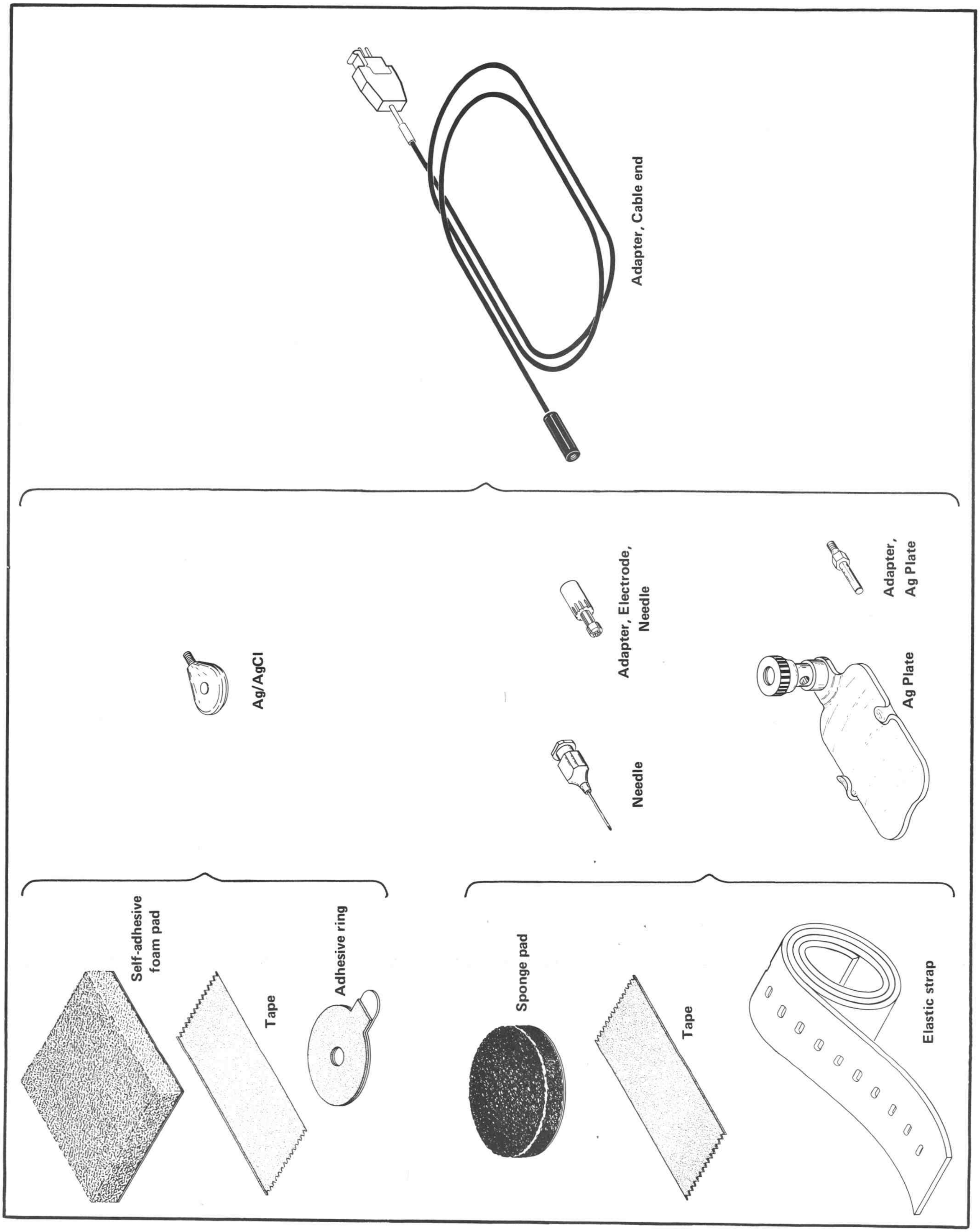


Fig. 2-21. Electrode adapter system and attachment methods.

SKIN PREPARATION

NOTE

Hair Removal—When the silver-silver chloride electrode is used, excellent electrode performance can be obtained in most cases without hair removal at the electrode site. These electrodes do not depend upon direct electrode to skin contact, but rather upon a saline jelly bridge between the two surfaces. The bridge can typically penetrate the hair. However, hair may prevent the use of adhesive tape or pads to mount the electrode, particularly upon the head. In some cases, electrodes can be held in place by elastic bands.

Proper preparation of the skin at the point of electrode attachment is most important for best results. If the skin is oily use a suitable cleansing agent such as alcohol or warm water and soap at the point of attachment of the electrodes. This will allow better penetration of the saline paste. See Fig. 2-22.

Rub a small amount (1/8 to 1/4 cc) of conducting paste (such as Day-Baldwin ® Electrode Paste) into the skin, rubbing with the finger tip until the area becomes reddened. The abrasive in the paste will remove many of the skin cells at the point of electrode contact and also force some of the conducting paste into the flesh, thus assuring good electrical contact. Electrode contact improves in the first few minutes as the electrode paste penetrates the skin.

When using adhesive rings to attach the electrode to the skin, remove all of the surface conducting paste so that the adhesive ring will stick to the skin. The adhesive rings help prevent evaporation of the conductive paste. Refer to the tissue diagram (Fig. 2-23) showing the electrode in place.

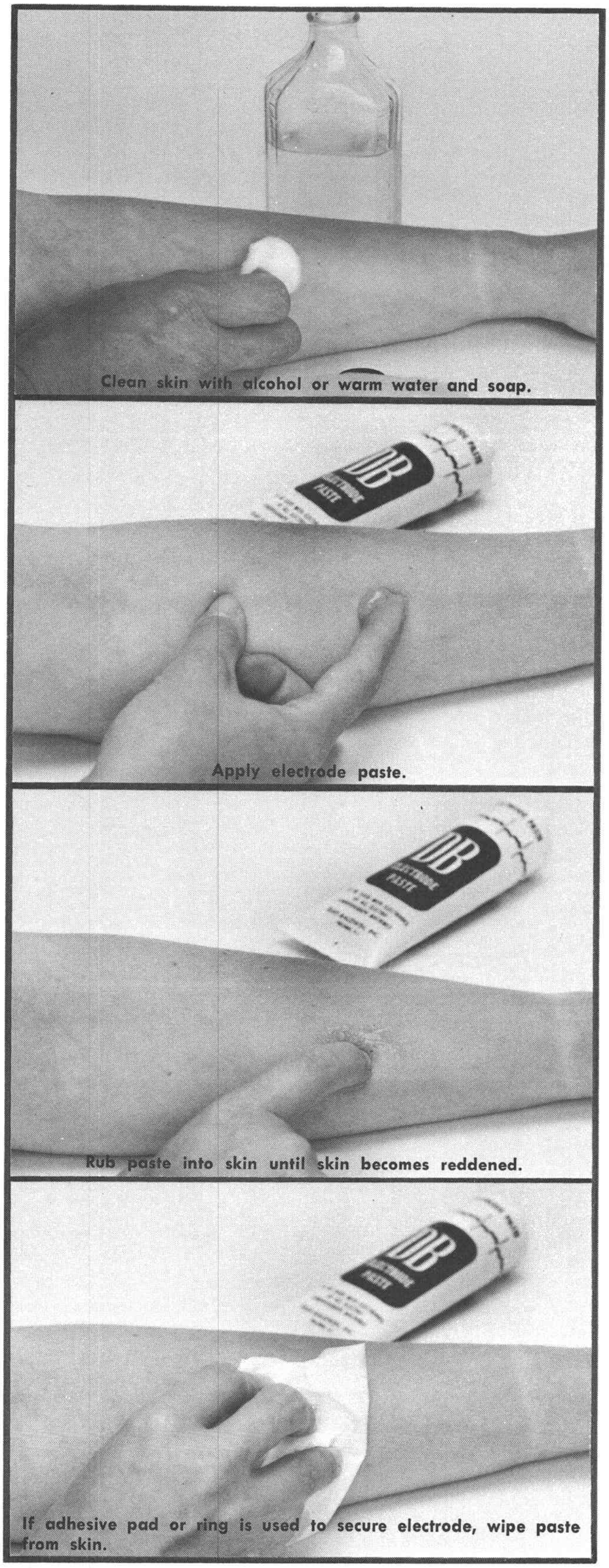


Fig. 2-22. Preparation of skin.

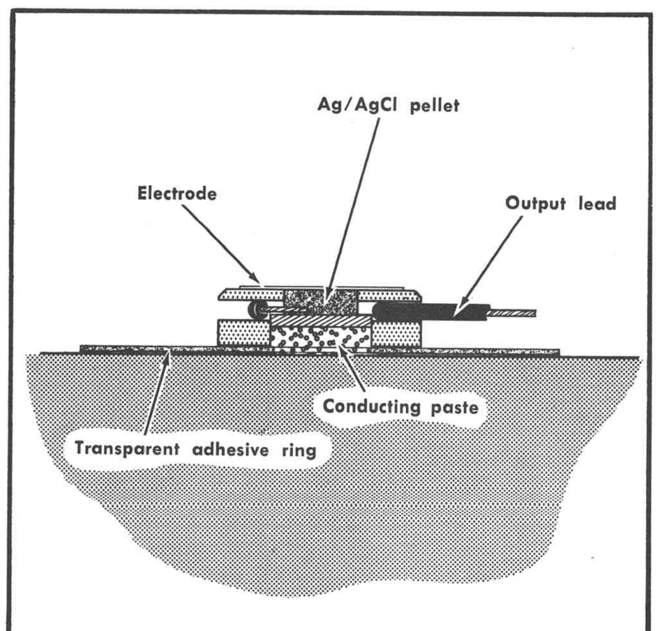


Fig. 2-23. Relation of electrode to electrode paste and tissue.

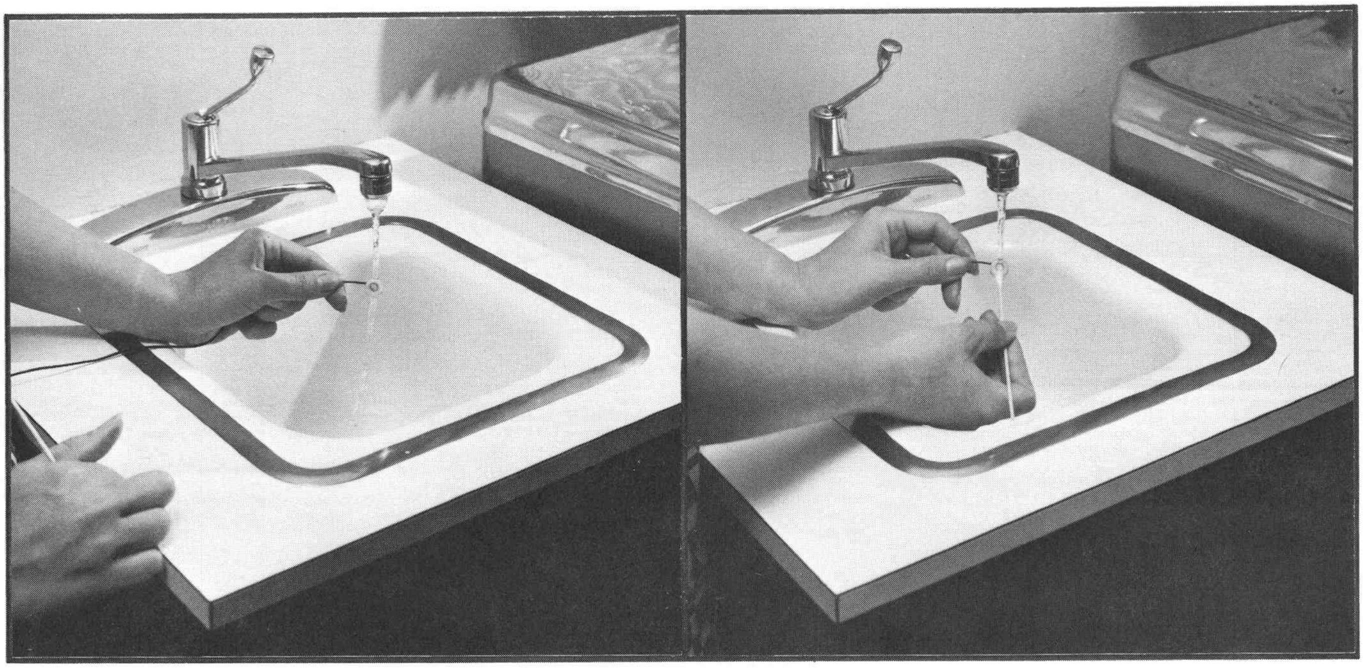


Fig. 2-24. Cleaning Ag/AgCl electrodes.

Cleaning Electrodes

The electrodes should be thoroughly cleaned with warm water after removal from the patient. The conducting paste should not be allowed to dry in the cup, as it then becomes more difficult to remove. Dried paste can be softened by soaking in warm water. Do not autoclave. Use cotton-tipped sticks (e.g., Q-Tips ®) as a cleansing aid. See Fig. 2-24.

Electrode Placement

Figures 2-25 through 2-32 show typical electrode placements for ECG monitoring

NOTE

Although the illustrations which follow show the electrodes placed just above the wrist (or ankle), any point on the appendage from wrist to shoulder (ankle to lower torso) would serve equally well. If the Type 410 is used only to detect the presence of heartbeat the electrodes may be attached to the back for convenience.

Electrodes other than the four Ag/AgCl supplied with the Type 410 may be used: for example, use the Ag/AgCl electrodes as the LA, RA, LL and C, a plate type for RL, and needle or other type electrodes for EEG, employing the adapter system supplied with the Type 410.

Electrodes need not be disconnected during defibrillation or electrical cautery.

FETAL ECG MEASUREMENTS

Normal Fetal ECG

Fetal ECG amplitude varies greatly with gestation time and also varies from one subject to another.

A typical fetal ECG obtained at 18 weeks is shown in Fig. 2-33A. The mother's ECG is clearly evident and, being many times greater in amplitude, may mask the fetal ECG. The fetal ECG can be observed between the mother's ECG waves.

Due to the low fetal ECG amplitude, the fetal R wave is normally the only part of the fetal ECG complex that is evident.

Subject Preparation

When attempting to record the fetal ECG using abdominal electrodes, it is imperative that the mother be in a state of complete rest, since the potential generated by muscular activity within the mother's abdomen will be present.

To reduce the mother's muscle activity in the abdominal area to a minimum, the subject should not eat for several hours prior to recording, and should empty her bladder shortly before recording.

Electrode Placement

It is now generally accepted that abdominal electrodes are preferred to most other configurations. The most common of the abdominal configurations is the Blondheim configuration, shown in Fig. 2-33B. Fig. 2-33 also shows two electrodes (G and H) on the back of the subject. During the early stages of pregnancy, a recording from one of these back electrodes may produce the most reliable results.

Electrode Combinations

In early stages of pregnancy, the following electrode combinations appear to give the greatest possibility of observing the fetal ECG: C-F, B-D, A-F, A-D, and if the G and H electrodes are used, G-F, G-D, and B-H.

In later stages of pregnancy, when fetal ECG is more pronounced, it is normally necessary to record only from electrodes A, F, and D or electrodes B, C, and E.

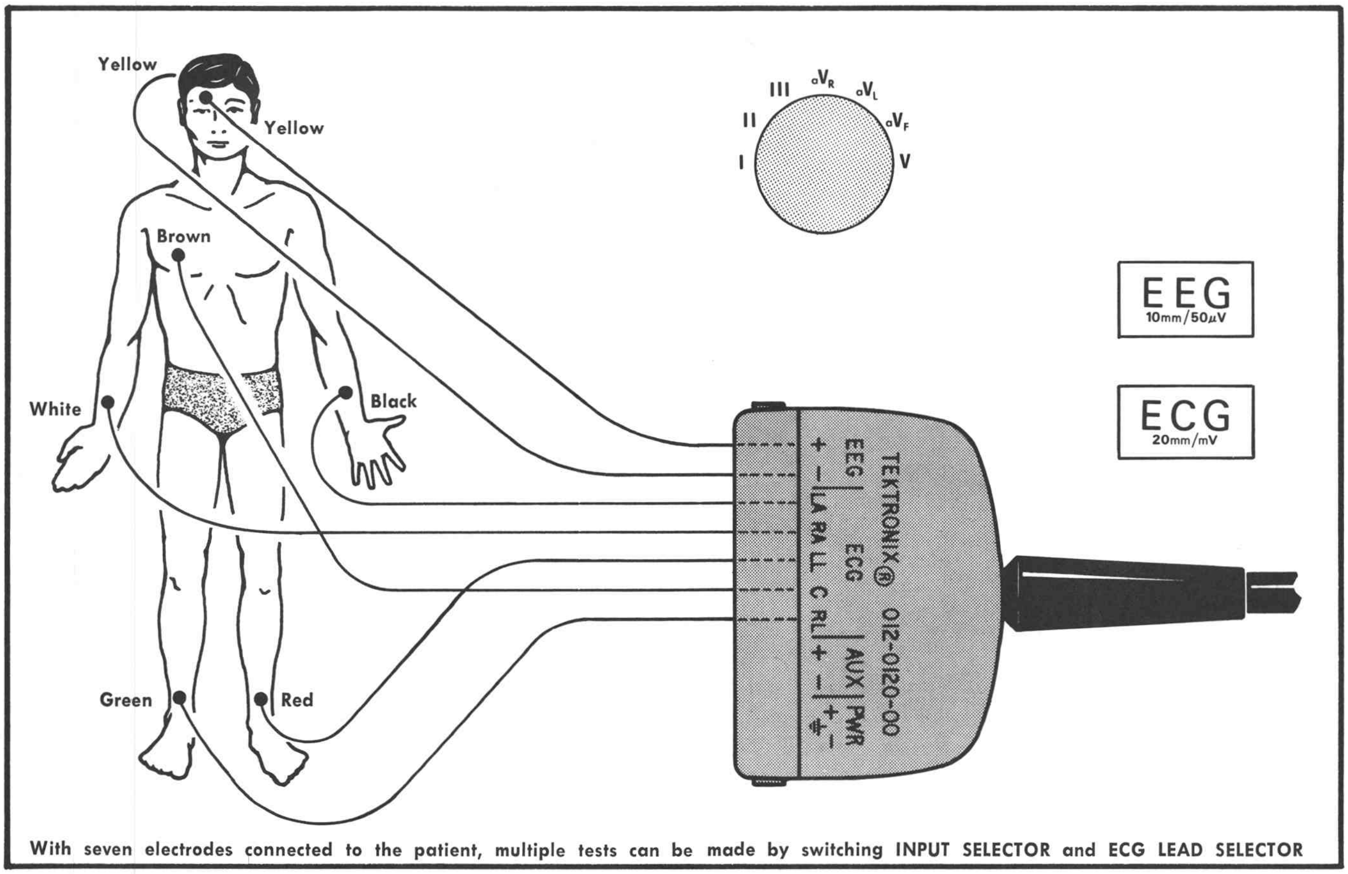


Fig. 2-25. Electrode placement.

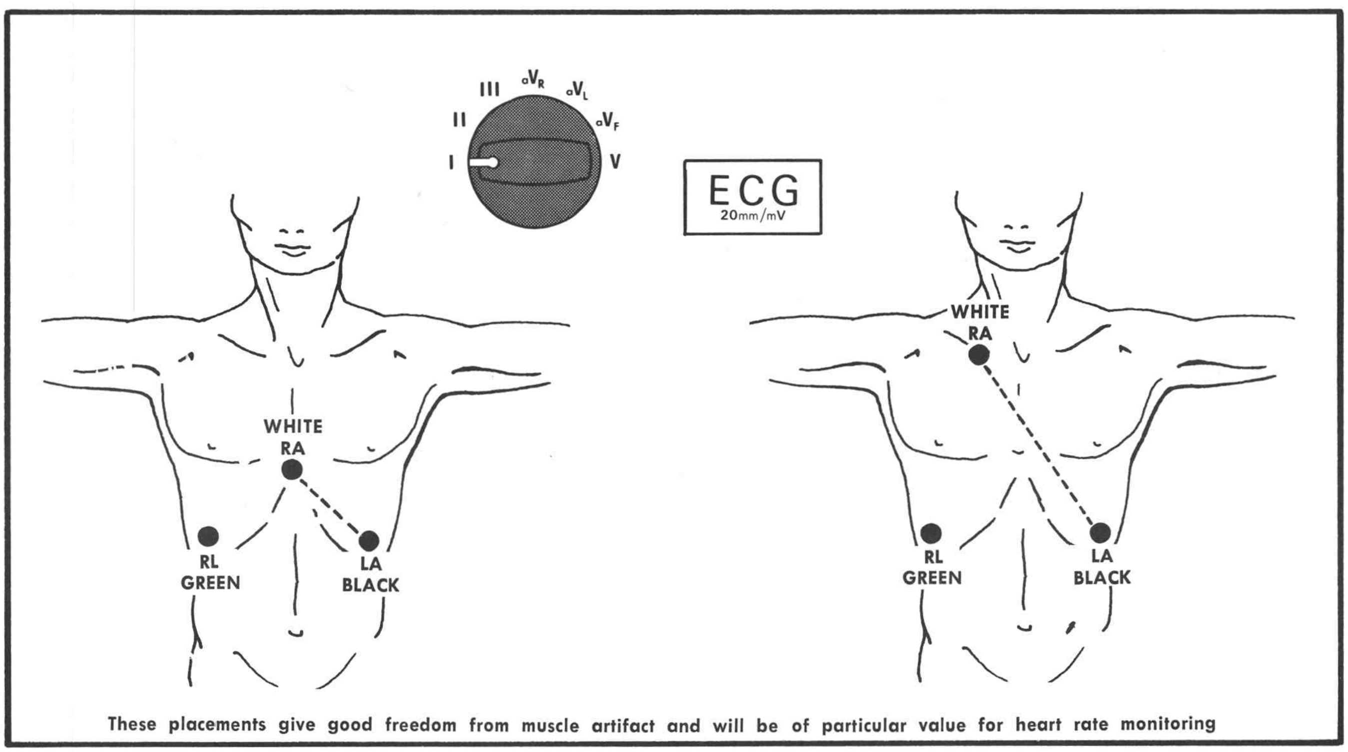


Fig. 2-26. Electrode placement.

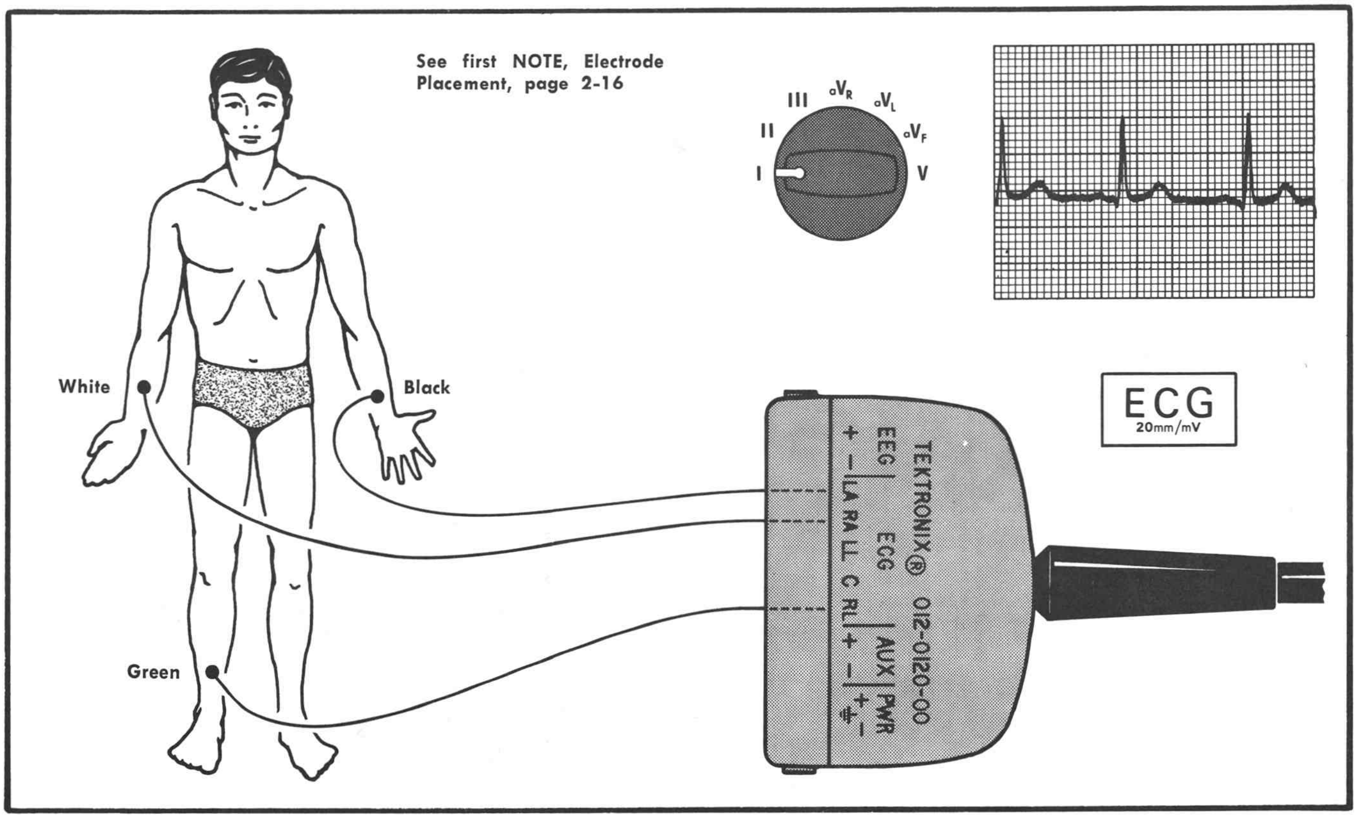


Fig. 2-27. Connections for lead configuration I.

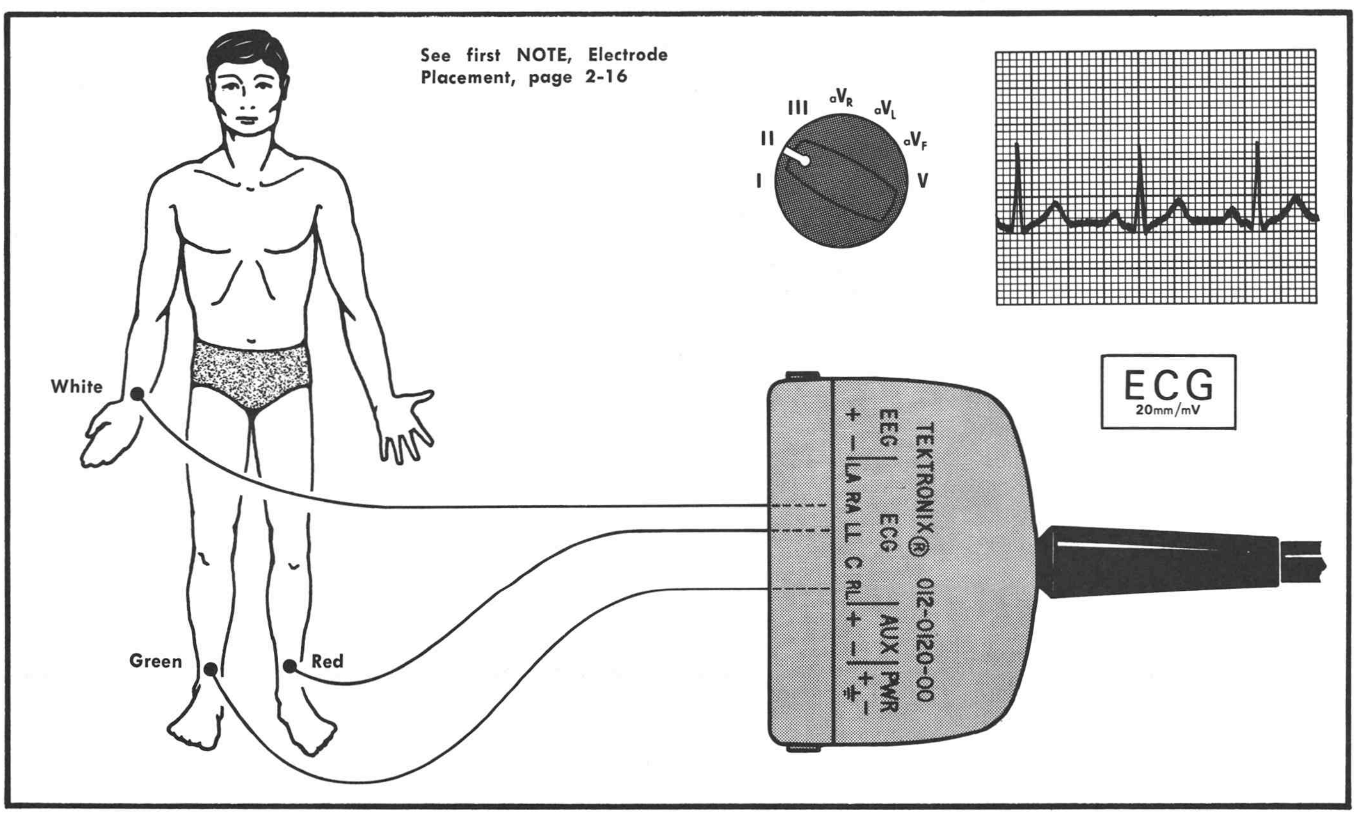


Fig. 2-28. Connections for lead configuration II.

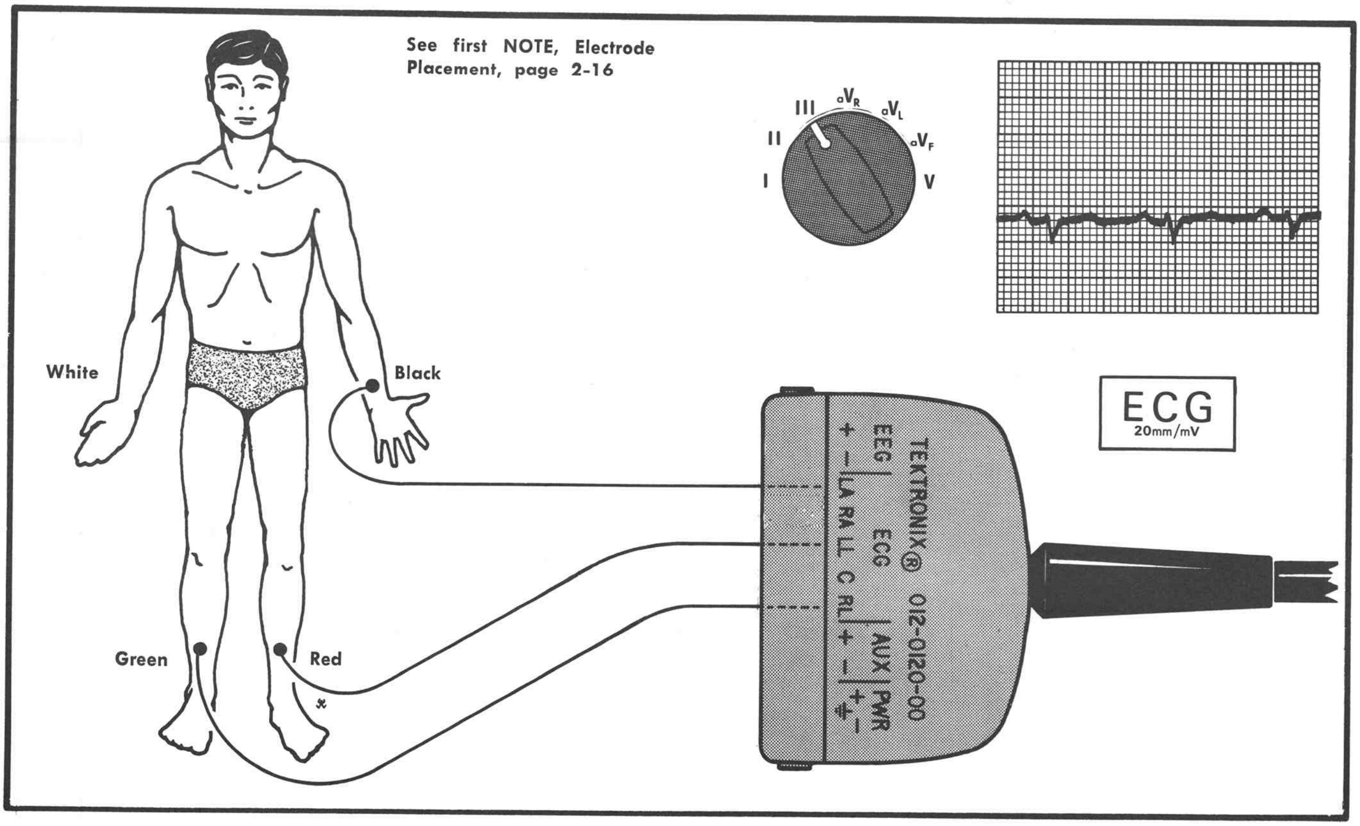


Fig. 2-29. Connections for lead configuration III.

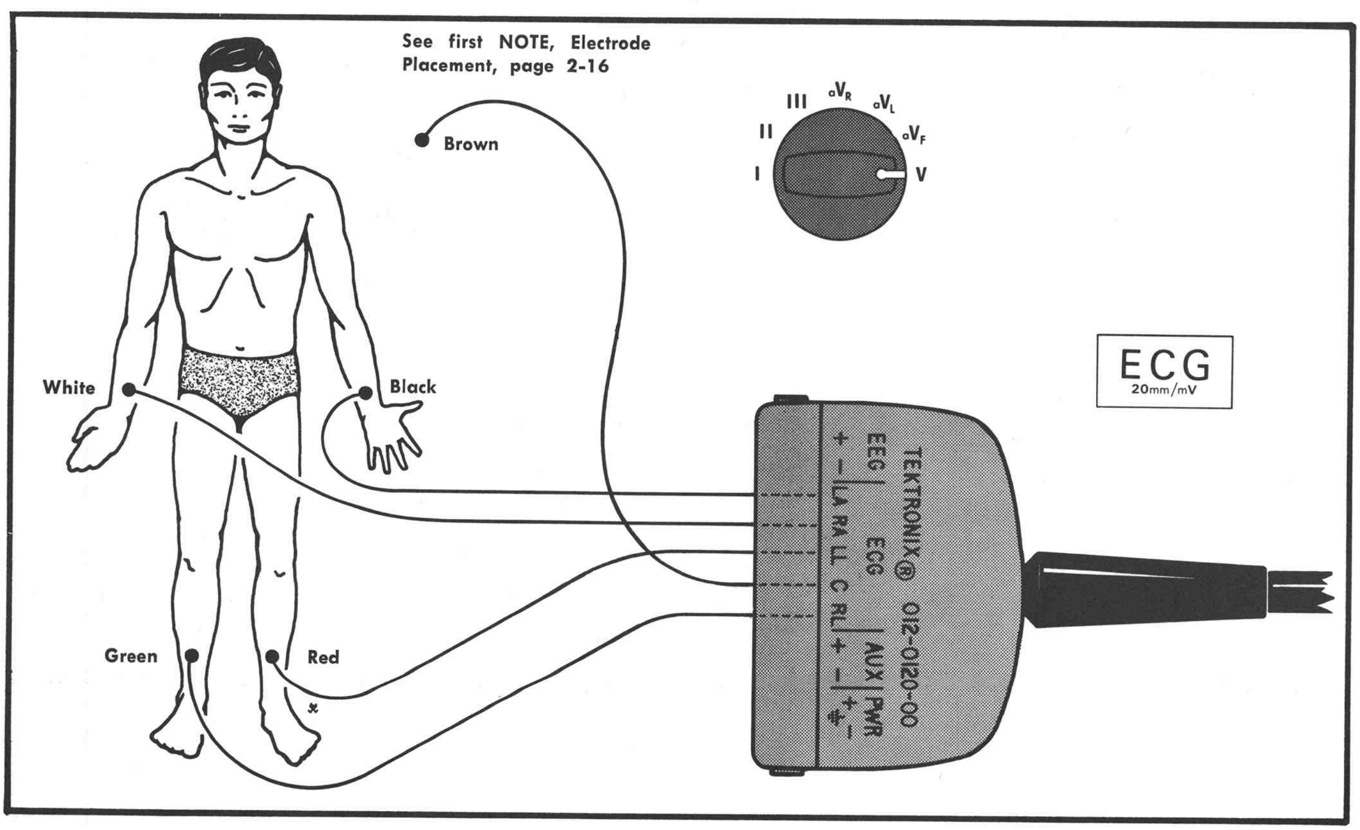


Fig. 2-30. Connections and switch position for V lead.

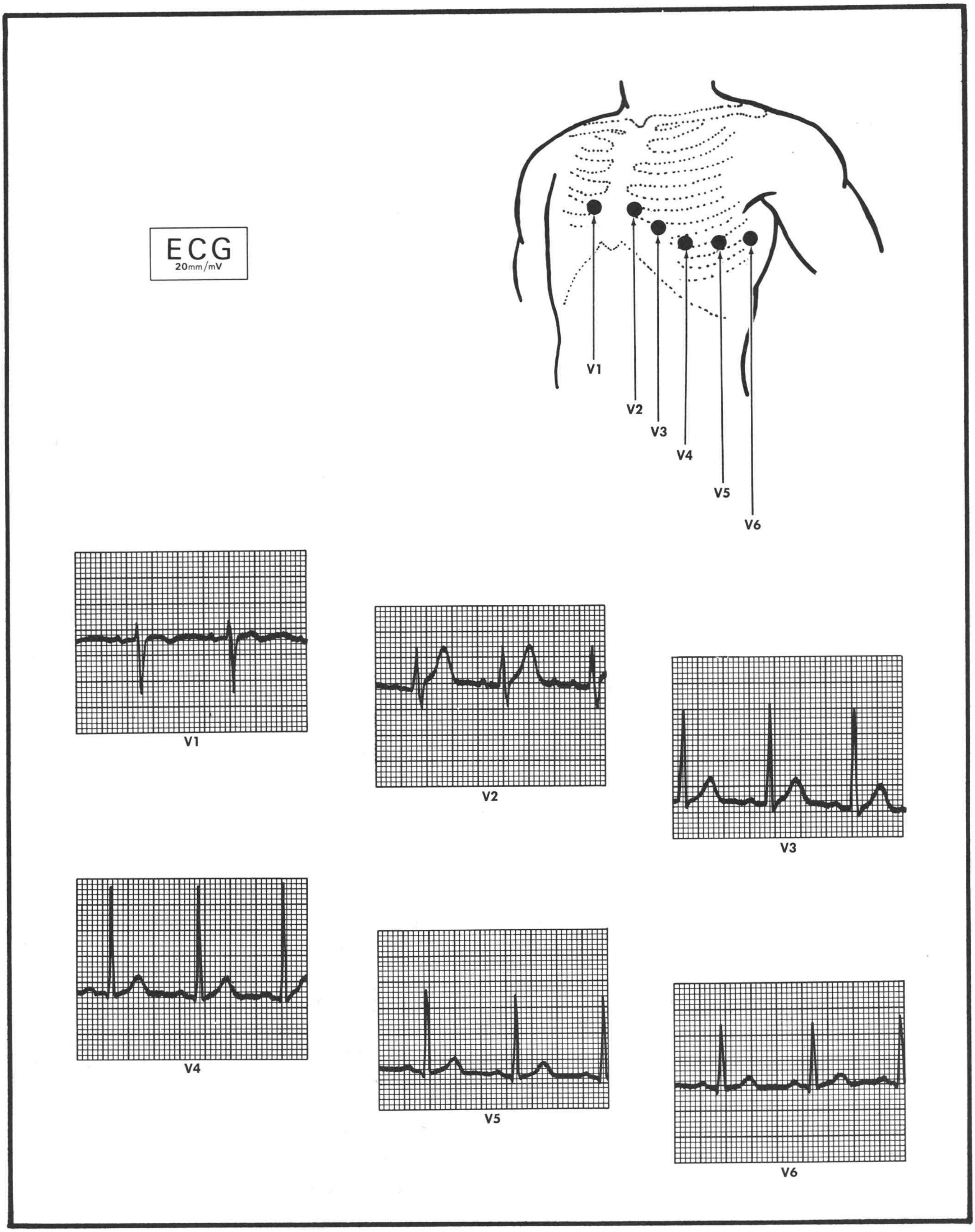


Fig. 2-31. Positions of exploring electrode and corresponding typical waveforms for V lead.

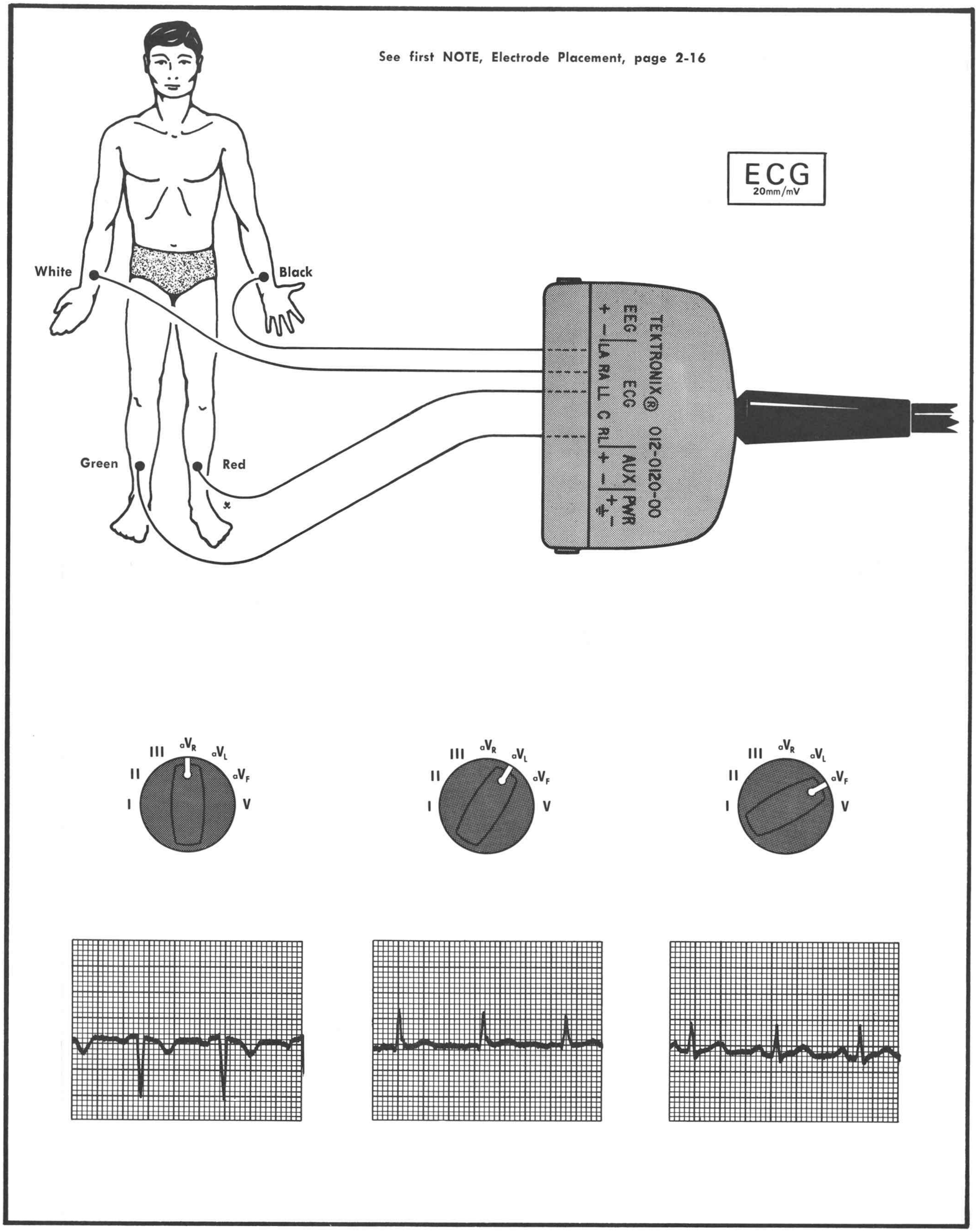


Fig. 2-32. Connections, switch positions and typical waveforms for aV_R, aV_L, aV_F leads.

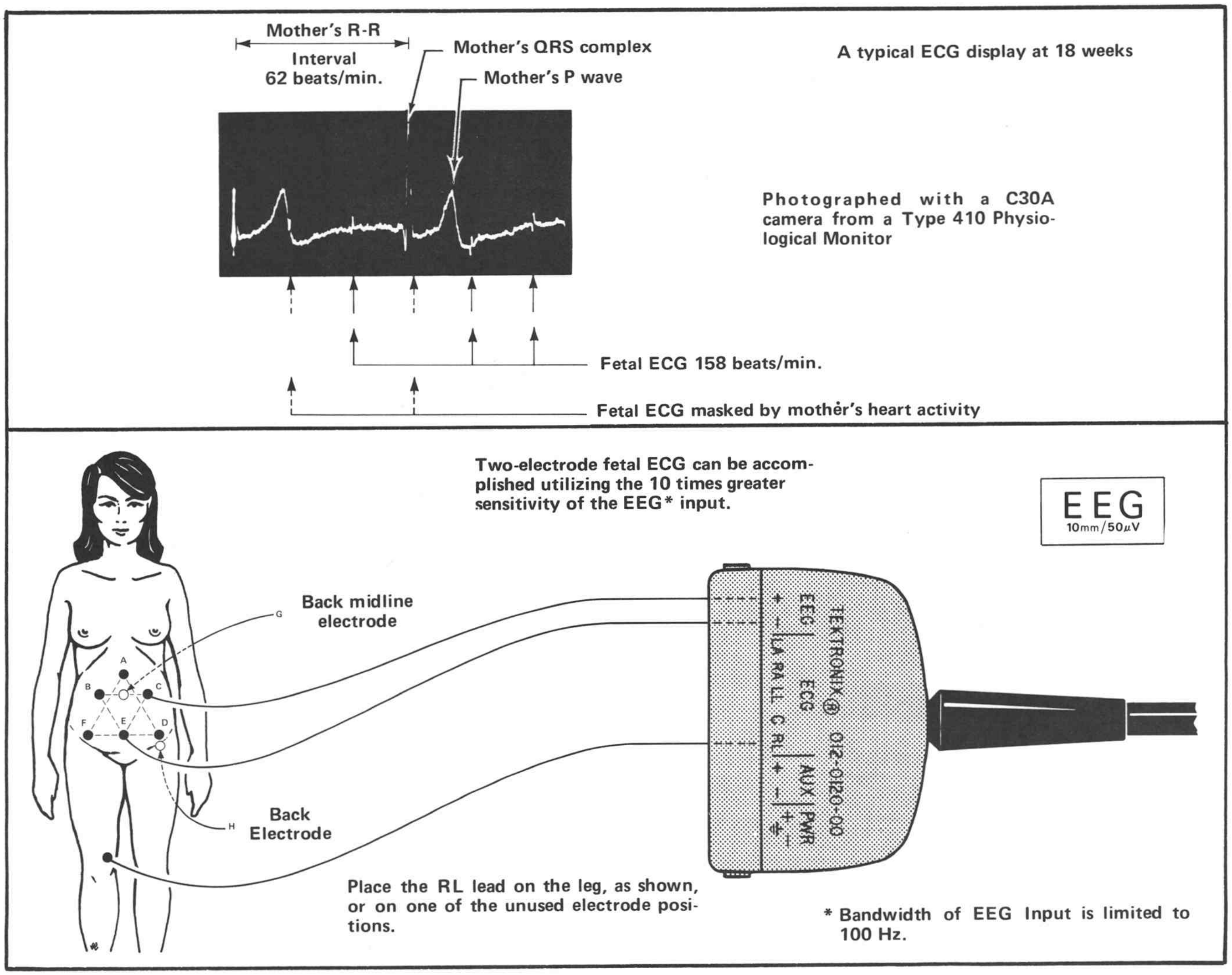


Fig. 2-33. Some suggested connections for two electrode fetal cardiology.

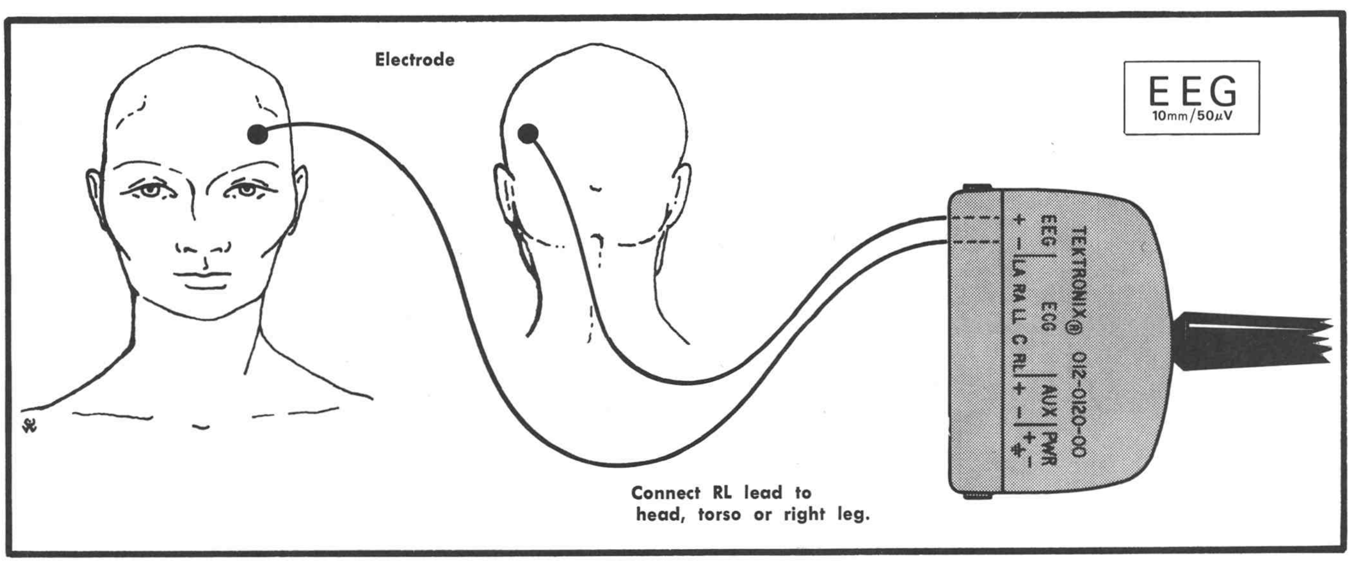


Fig. 2-34. One of a number of possible electrode placement sites.

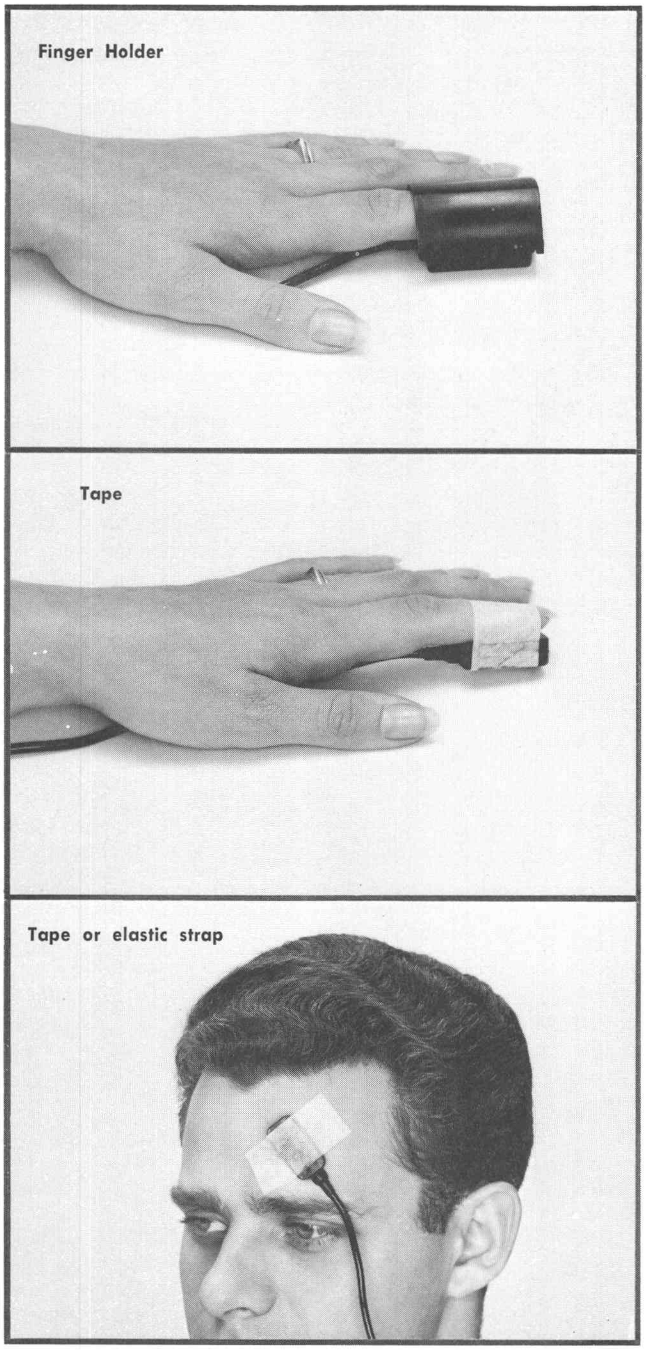


Fig. 2-35. Methods of attaching the Pulse Sensor.

Using the Type 410

Use the EEG position of the function selector switch (INPUT SELECTOR) and connect the fetal ECG electrodes to the EEG position on the patient cable.

The standard Type 410 should give satisfactory results. However, the low frequency response may allow the muscle activity within the mother's abdomen to cause the trace to be off screen most of the time. This problem can be overcome by altering the low frequency cutoff characteristics by replacing C134 and C234 (see Fig. 4-16 on the Vertical Circuit board) with 0.1 μF capacitors. Use this modification *only for fetal ECG measurements* as the display amplitude is reduced for lower frequency signal components (normal ECG, etc.).

Set the VERTICAL SIZE control fully clockwise for maximum display amplitude.

Electrical Interference

Particular care must be taken to eliminate line frequency interference from the fetal ECG recording.

Filters can not be used, because the primary frequency content of the fetal ECG is between 20 and 80 Hz. Line frequency interference can usually be eliminated when recording the fetal ECG by operating the Type 410 from its internal battery and by completely disconnecing (rather than simply turning off) other power-line-operated devices in the near vicinity. Interference may be eliminated in many cases by orienting the patient in a particular position in the room.

The leads that connect the patient to the monitor should be as short as possible preferably two feet or less.

For additional information, including interpretations, on fetal ECG measurements refer to the Tektronix publication, Biophysical Measurements. The Tektronix Part Number for this publication is 062-1247-00.

Fig. 2-34 shows approximate location of one of several desirable electrode placement sites for EEG monitoring.

PULSE SENSOR

Description

The pulse sensor consists basically of a light source and photoresistor. The light source emits a constant light level and the light is reflected by the flesh to the photoresistor. The changing reflected light changes the resistance of the photoresistor, producing a varying voltage out.

Application Sites

The pulse sensor operates on the variation of light transmission and reflection of the flesh which results from the slight swelling and contraction of the capillaries during each blood-pressure cycle. Thus, a fairly high concentration of capillaries near the surface of the skin is required. Sites such as tips of fingers, tips of toes and forehead are particularly well suited as monitoring sites. See Fig. 2-35 for attachment methods.

There are some physiological variations that are evident in some sites and not in others. In reaction to drugs, anesthetics, skin temperature and other external stimuli, the extremities have a tendency to change blood flow. If pulse rate is the only information required, a stable waveform is desirable. Thus, for freedom from the effects of drugs, anesthetics or skin temperature, the forehead may be the best monitoring site. Conversely, if the pulse sensor is to be used as an indicator of vasodilation or vasoconstriction the finger or toe site would be indicated. Furthermore, the sensor is more easily mounted on the finger or toe.

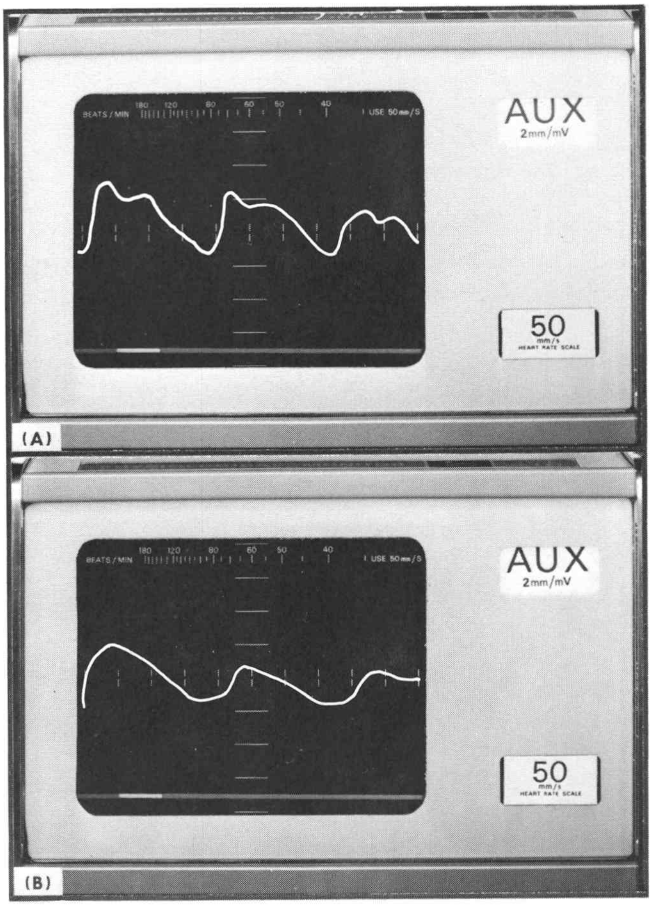


Fig. 2-36. (A) Typical pulse waveform. (B) Restricted flow (limb lying across solid object).

While skin pigmentation appears to have no effect on the usefulness of the sensor, heavy calluses may disrupt the optical path to such an extent that little or no signal is obtained.

In marginal cases there is some evidence that optical coupling may be improved and usefulness of the sensor enhanced by the use of a small amount of glycerin on the skin (in the area beneath the light source and photoresistor).

Finger Holder

The sensor, when used in the finger holder, must be positioned correctly for best results.

Note the detent recesses in the side of the sensor which match the detent bumps inside the finger holder. Place the sensor into the finger holder and push gently until the sensor snaps into the holder. When in place properly the sensor should pivot freely on the detents.

Be sure that the fleshy portion of the finger tip is well centered over the optical window. Force the finger into the opening letting the finger spread the holder open. Once the finger is in place gently squeeze the holder to ensure that the condition of the tilting action and spring pressure properly seat the finger.

To remove the sensor from the finger holder, push through the large hole in the bottom of the finger holder.

Maximum Temperatures

A series of tests on Tektronix pulse sensors has indicated that the heat produced by the sensor lamp can typically be considered non-hazardous, even when blood circulation fails or is reduced.

The temperature of the surface of the light source was measured using a block of vinyl to simulate a finger with no circulation. The maximum temperature was found to be 118°F in an ambient temperature of 72°F.

With adults having normal circulation, the maximum temperature was under 100°F in a72°F ambient.

Even in the unlikely event of catastrophic component failure in the sensor, the maximum dissipation is limited to a reasonable level by two 62 Ω resistors in the Type 410 monitor.

The pulse sensor does not indicate absolute pressure and is therefore not a substitute for a sphygmomanometer. However, the sensor can be used with the sphygmomanometer as a visual indicator (as opposed to observing the Korotkoff sounds with a stethoscope) to determine the point at which the manometer cuff has properly restricted the flow of blood.

The sensor can probably not be used successfully on an exercising patient since the sensor is sensitive to position and/or pressure changes.

In the presence of fluorescent or arc type light sources, take care that the light does not reach the sensing cell. Since flesh is translucent, light may reach the cell indirectly and optically introduce interference at twice the line frequency.

The sensor is not affected by defibrillation or cautery because of the optical coupling to the patient.

Note that the waveform varies with the position (above or below the level of the heart) of the sensing device. Unwanted restrictions to the free flow of blood such as taping the sensor too tightly to a limb or the limb lying across a solid object will produce a distorted signal. See Fig. 2-36.

MEASUREMENT PROBLEMS

Interference

Electrostatically induced interference is basically caused by large and/or rapid voltage changes in nearby equipment or wiring. The best way to eliminate the interference is to place a grounded conductive shield between the interfering source and the measurement site, preferably surrounding the source. Since this is often impractical, the next best is shielding of the monitoring equipment and its environment. The Type 410 and its cables are electrostatically shielded, but since it is also impractical to shield the patient, the interfering signals can be imposed upon the body and to some degree, will become mixed with the desired signal.

Except in the most severe cases, the mixing effect within the body will be negligable and will not interfere with the display. Far more significant interference can occur if electrodes having unshielded wire are used. Two factors will minimize the interference; good electrode contact and minimum length of unshielded wire.

Electromagnetically induced interference is basically caused by large and/or rapid current changes in nearby wiring or

equipment such as motors, transformers, diathermy, X-Ray, radio and TV transmitting antennas, etc. Blocking electromagnetic radiation at the source is most often difficult or impractical and in the case of radio or TV transmitting antennas, is undesirable.

Electromagnetic interference may be minimized in the Type 410 display (especially in EEG measurements) by twisting the electrode leads together over as much of the lead length as possible.

Interfering signals of a transient nature may cause the display on the Type 410 to be driven off screen, but since the Type 410 has a direct coupled input and scan limiting, the recovery time after the interfering pulse is very short (2 to 4 seconds).

All measurements should be made with the RL lead connected to the right leg (except in the case of EEG, where the RL lead may be connected to the upper torso or head). The RL lead provides a ground reference and helps to limit or minimize interference.

Muscle Artifact

Since electrical signals accompany all muscle motion, the patient should remain quiet during ECG monitoring. These signals can be of such amplitude (in the millivolt range) as to mask the signal of interest. Minimum muscle artifact will be encountered with chest leads as shown in Fig. 2-26. The short distance between electrodes and the typically small movement of chest muscles when using chest leads for ECG measurements make it unnecessary for the patient to remain perfectly quiet.

PATIENT SAFETY

Electrical

The following features and provisions of the Type 410 provide maximum protection against electric shock:

Battery operation: No power line connection is needed.

The instrument, when operated from the power line, is isolated from the line by the transformer in the charging circuit.

Solid state circuitry: Unlike vacuum tube circuitry, the Type 410 utilizes very low voltages and currents within the instrument. Even in the unlikely event of internal component failure, both current and voltage are limited to values much less than those used in vacuum tube circuitry.

Multiple semiconductor failures in the vertical amplifier would have to occur in order to provide a low impedance path from the highest supply voltage in the vertical amplifier to the patient. Even then, the return path is 100,000 ohms via the RL lead unless the patient is grounded by some other method and the Type 410 is also grounded via the charger power cord.

Protective current-limiting devices in the Type 410 input virtually eliminate any chance of multiple semiconductor failure in the vertical amplifier due to external causes. The same bidirectional devices that limit input current to a non-destructive level also protect the patient by limiting the current to less than 300 microamperes from the instrument to the patient in the very unlikely event of internally caused multiple semiconductor failures.

CAUTION

The input protective circuitry of the Type 410, while protecting the patient in normal monitoring of ECG and EEG, will not limit the current to a value that could be considered safe for monitoring with leads implanted directly in or upon the heart.

GROUNDING

Line

The power cord must be used when external line-operated equipment is connected to the Type 410 OUTPUT connector. The power cord must be connected to a grounded 3-wire receptacle.

The third wire (ground) in the 3-wire power cord connects to the battery center tap, referred to as circuit ground.

Case

The CASE GND binding post need not be grounded when the power cord is used. If it is connected to ground it will not introduce significant ground loops.

When the power cord is not connected to a voltage source, the case may be grounded as added protection against any voltage source (which might contact the case) reaching the patient.

For SN B010100 through B099999:

The case is isolated from circuit ground by 330 kΩ paralleled by 0.01 μF.

If the case is not grounded, the patient is isolated as follows:

1. 330 kΩ paralleled by 0.01 μF between case and circuit ground.

2. 100 kΩ between circuit ground and RL.

3. Protection networks at the Type 410 Vertical Amplifier input.

For SN B101215 and up:

If the case is not grounded, the patient is isolated by (1) 100 kΩ between circuit ground and RL and (2) protective networks at the Type 410 Vertical Amplifier input.

WARNING

When used in areas where flammable anesthetics are in use as defined in NFPA 56, Sections 2438, 2842 'c' and 2484 this instrument must be located at least five feet above the floor and the external power cable must be disconnected.

NICKEL-CADMIUM BATTERIES

General

The nickel-cadmium cells supplied with the Type 410 were selected as a result of extensive evaluation and should provide a useful operating life over several thousand charge-discharge cycles.

Precautions

To obtain the maximum useful life of the nickle-cadmium cells used in this instrument, observe the following precautions:

1. Do not operate the instrument when the spot is in the red area of the battery charge scale (on BATTERY CHECK).

2. Observe the temperature limits given in the charging information.

3. Don't charge the batteries for long periods of time when the instrument is not being used. While no harm will be done if charge is continued for a week or two, longer charge periods should be avoided.

NOTE

Failure to observe these precautions may cause damage to individual cells or may shorten cell life considerably.

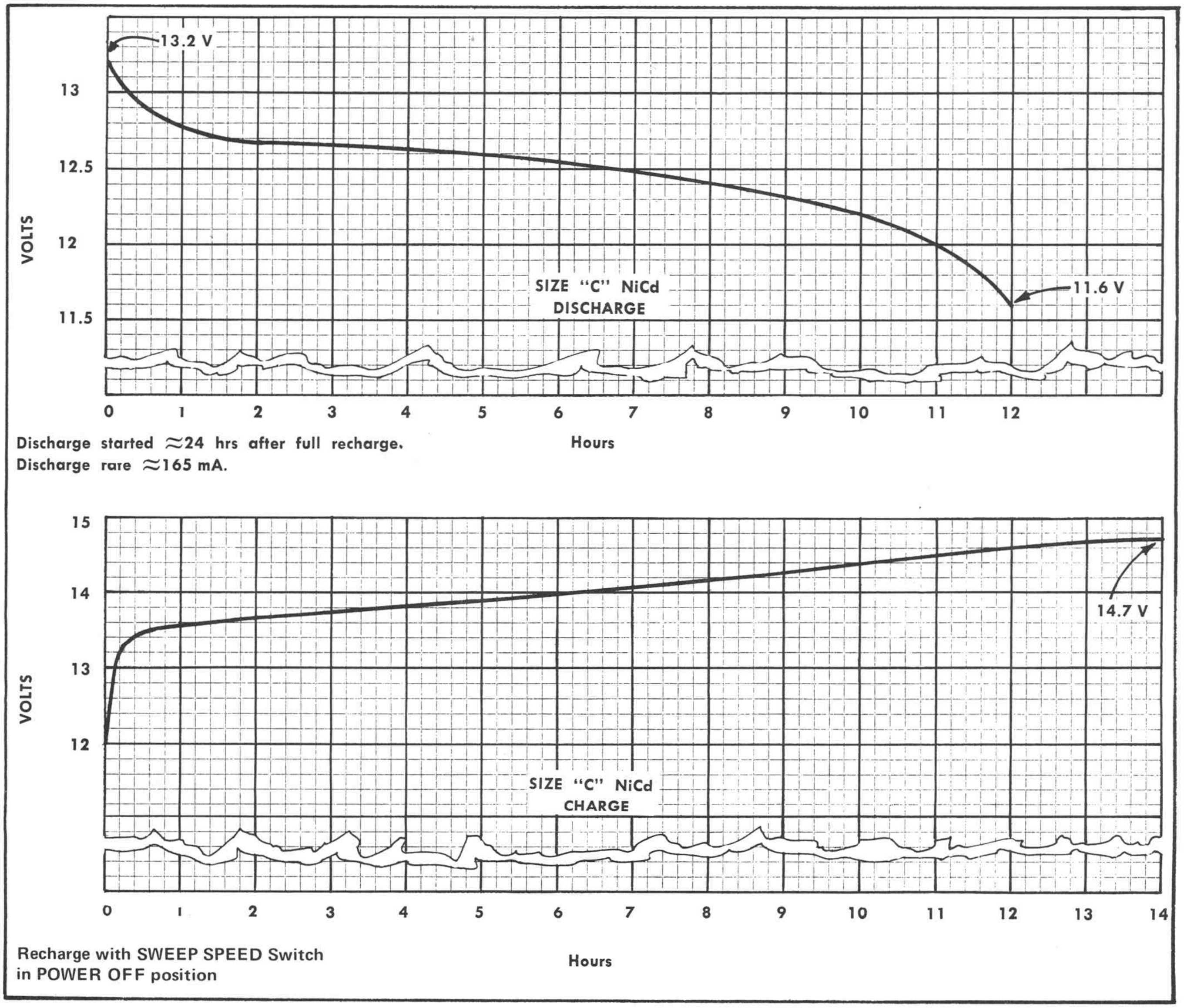


Fig. 2-37. Typical voltage levels during charge and discharge of Nickel-Cadmium batteries.

Construction

The cells supplied with the Type 410 are the rechargeable alkaline (nickel-cadmium) type. They are characterized by great resistance to mechanical shock, vibration and physical damage.

The cells are sealed and may be operated in any position.

Electrochemical

Any secondary cell uses the reaction between active materials that can be electro-chemically oxidized and reduced (de-oxidized) repeatedly. The oxidation of the negative electrode, simultaneously with the reduction of the positive electrode generates electric power. In rechargeable cells both electrode reactions are reversible. Current fed into a cell in the proper direction will cause a primary reaction in the opposite direction and recharge the electrodes.

During the latter part of full charge cycle, and during overcharge, nickel-cadmium cells generate gas. Oxygen is generated at the nickel electrode and is recombined with cadmium at the negative electrode. Hydrogen is generated at the cadmium electrode during deep discharge polarity reversal and does not recombine. Therefore, any hydrogen generated during polarity reversal builds up pressure within the cell. Overpressure within the cell will be released by the action of the resealing vent. The result is shortening of cell life. Because of this, deep discharge should be avoided by discontinuing operation when the BATTERY CHECK indicates in the Red zone.

Characteristics

During discharge, the average voltage per cell is approximately 1.2 volts. When discharged at low currents, over several hours, the voltage curve is very nearly flat until the cell approaches complete discharge.

Voltage levels also vary depending on the operating mode, i.e., charge, discharge, temperature, etc. Typical voltage levels during charge and discharge are shown in Fig. 2-37.

Capacity

The 1.8 ampere-hour (new-cell rating) cells supplied with the Type 410 will deliver 0.36 amperes for 5 hours. If current is withdrawn at a lower rate, as in the Type 410, the available ampere-hour capacity is increased slightly. End of life, by definition, is reached when the cell will deliver only 80% of its rated ampere-hour capacity.

The cells supplied with the Type 410 provide maximum ampere-hour capacity at normal room temperature, 25° C. Some loss of capacity will be experienced at temperatures above and below room temperatures.

State of Charge Indication

Measuring the state-of-charge condition of nickel-cadmium cells is, at best, difficult to accomplish.

The most workable means, within the confines of practical circuitry is to monitor the battery terminal voltage near the end of discharge, where the voltage begins to decrease fairly rapidly as it falls below approximately 12 volts. In the Type 410 the battery is considered to be discharged when the terminal voltage under load is equal to or less than 11.9 volts.

The Type 410 BATTERY CHECK Scale is the readout for a slide-back expanded scale voltmeter that monitors one half of the battery.

Sweep length on all three sweep speeds is also a direct indication of battery terminal voltage. The sweep is calibrated to end at the tenth centimeter with a battery voltage equal to that which places the Battery Check indication at the break between the green and yellow zones. The end of the sweep will move to the right approximately 5 millimeters per volt of battery terminal voltage increase.

Therefore, a sweep length extending beyond the 10 centimeter mark indicates remaining battery capacity. When the sweep shortens to the 10 centimeter graticule mark the end of discharge is approaching, and the battery charge condition should be checked more closely by switching the SWEEP SPEED Selector to BATTERY CHECK.

Cycle Life

The cells supplied with this instrument should have a life in daily service of several years.

While the battery will not be harmed if discharged to the break between the red and yellow zones of the Battery Check Scale, there is some evidence that somewhat longer battery life may be expected if discharge is terminated before reaching the yellow zone.

Polarity Reversal

Avoid discharging the batteries in the Type 410 down into the red area on the Battery Check Scale. Since there are small differences in ampere-hour capacity of individual cells, one cell may reach complete discharge sooner than others. Continued current from the other cells in the battery could cause polarity to reverse on one or more cells.

Hydrogen gas generated during reversed polarity results in a pressure buildup that is irreversible.

Since the cell is protected against overpressure by a resealing vent, the cell will not be physically damaged. However, cell life may be shortened considerably.

Charging

The battery should be charged whenever the Battery Check Scale indicates low charge condition (yellow or red areas or low in the green area) or after storage of 25 or more days at room temperature. At temperatures higher than normal room

temperature, the battery will have to be charged more frequently. If there is any doubt, charge the battery.

Maintenance

No maintenance except charging is required on the nickel-cadmium cells supplied with this instrument.

The cells have a long, active life and the storage period, within the temperature limits for storage, is approximately 5 years. The ideal storage temperature for best shelf life is 20° C (68° F). Charge condition while in storage has little effect on storage life.

Protective fusing is provided in the battery pack for the power line and for the battery load. Spare fuses are provided and are contained in the battery pack. See Fig. 2-38.

Operating Temperatures

The Type 410 should be operated at ambient temperature no higher than +40° C (104° F) but best battery operating time per charge will be realized if the batteries are charged at approximately +20° C (+68° F). The instrument may be stored at higher temperatures +60° C (+140° F). The instrument may be stored with the battery at temperatures down to —40° C (—40° F) and may be operated down to +10° C (+50° F).

Neither the instrument nor the battery pack can be autoclaved.

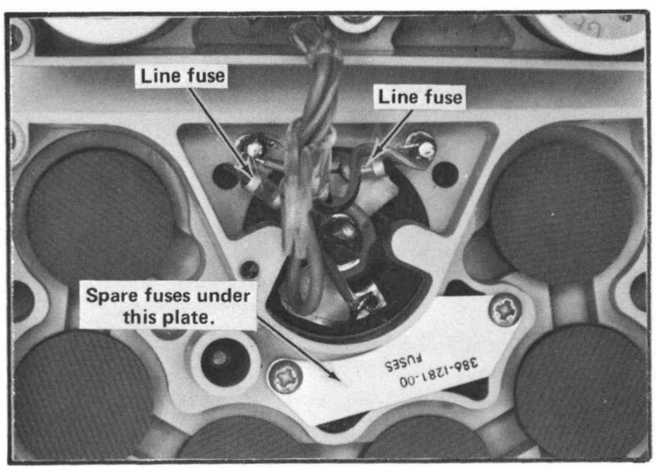


Fig. 2-38. Location of spare fuse in battery pack.

Electrical Loads

The AUX PWR terminals on the Patient Cable terminating block provide +6.7, ground, and —6.7 volts to supply battery for auxiliary equipment, such as the Pulse Sensor. Current drawn by auxiliary equipment should be limited to approximately 30 mA.

MAINTENANCE

When disassembling the instrument and battery pack, several important points must be considered. These points,

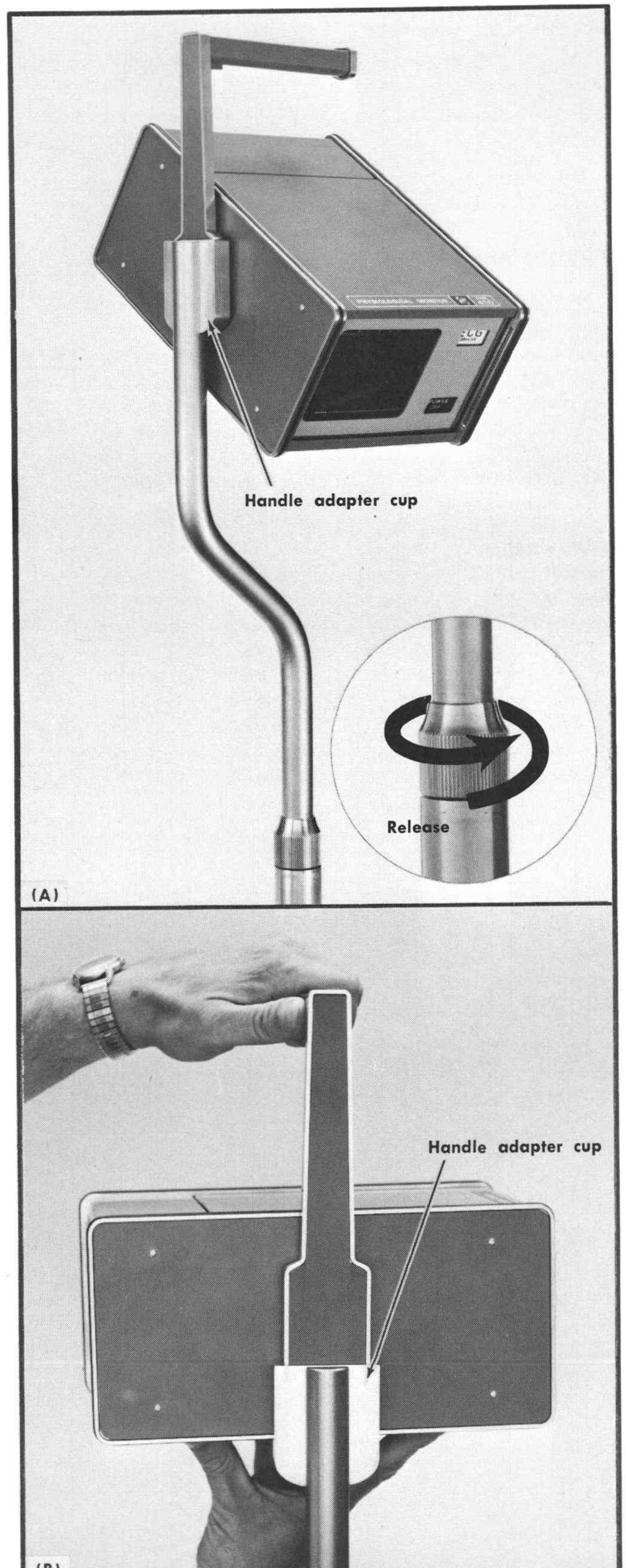


Fig. 2-39. (A) Type 410 mounted on stand. (B) Inserting instrument handle into handle adapter cup.

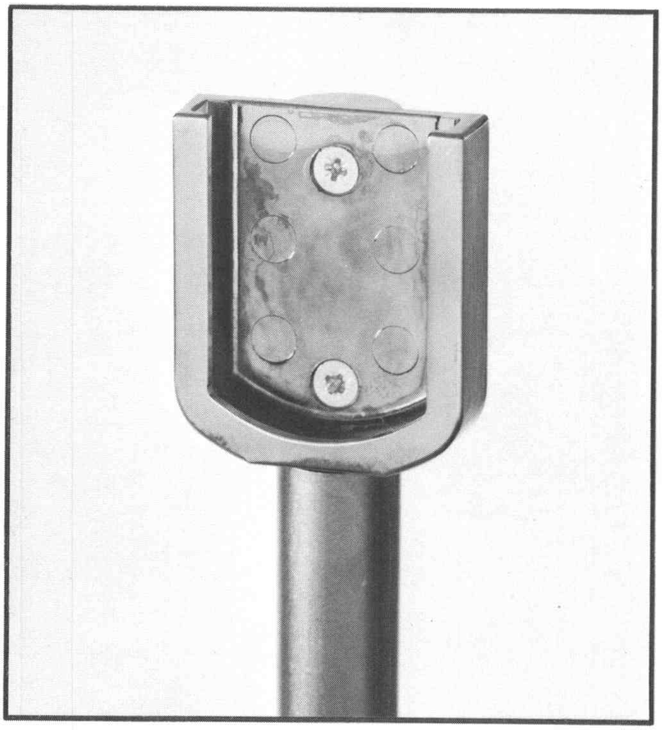


Fig. 2-40. Handle Adapter Cup.

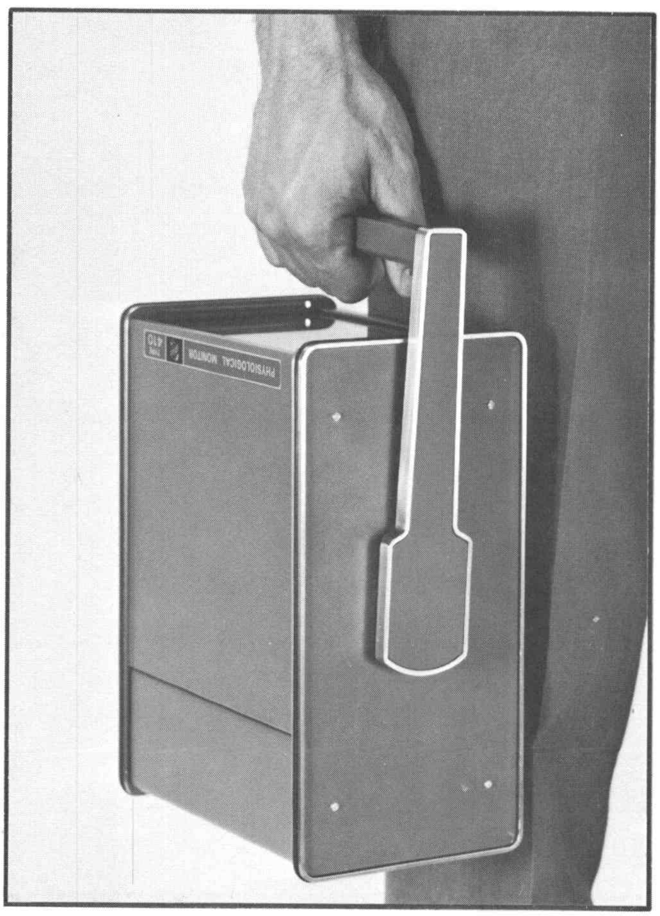


Fig. 2-41. Position of handle for most convenient carrying.

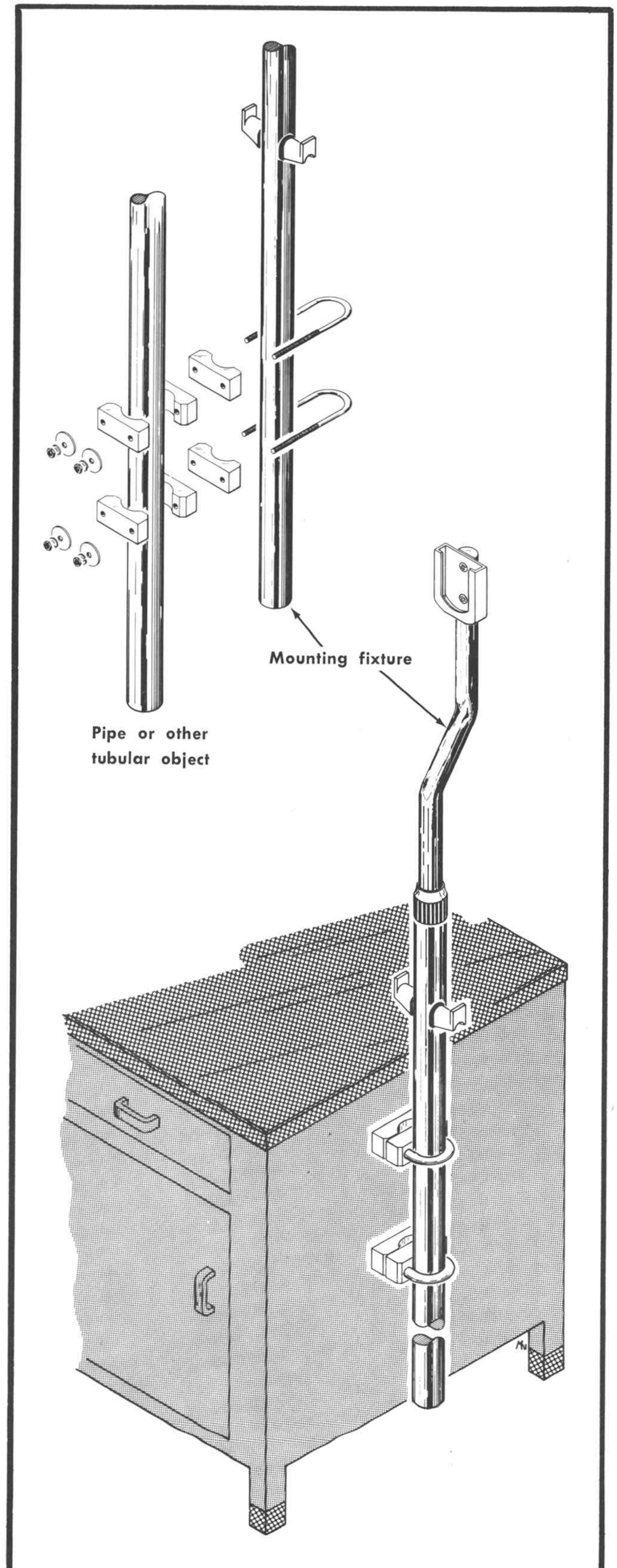


Fig. 2-42. Method of mounting to tubular object (pipe) or side of cabinet.

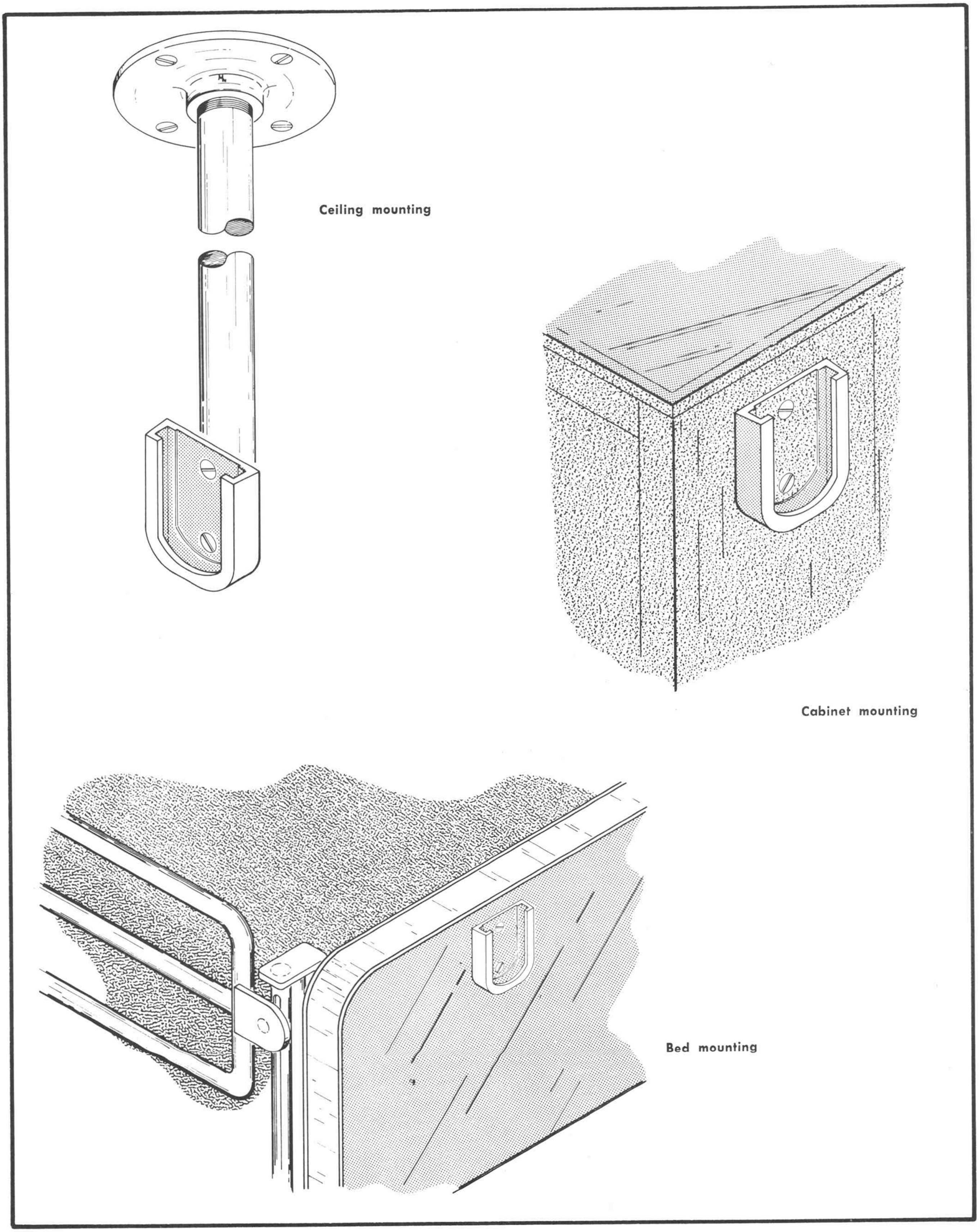


Fig. 2-43. Optional Handle Adapter Cup mounting methods.

listed below, are covered in detail in the Maintenance Section of this manual.

1. Current capabilities of the batteries.

2. High voltage charge on capacitors after the instrument is turned off.

3. Implosion hazards of the cathode-ray tube.

Table 2-4 lists the external surfaces and the materials of which they are made, or with which they are coated. Avoid cleansers which will harm these materials.

TABLE 2-4

Instrument Part	Material
Cabinet (painted surfaces)	Vinyl base paint
Side castings	Chromium plating
Battery case, Handle grip and spacers, Potentiometer washers	Delrin® plastic
Knobs	ABS Plastic
Handle end cap	Nickel plating
Lettering	Enamel ink
Gaskets	Neoprene
Support chassis (rear bulkhead)	Lacquer
Speaker cone and spacers	Paper or fiber
Tags	Anodized aluminum
Screws	Cadmium plating

The recommended method of cleaning the exterior surfaces of the instrument is with warm water and mild soap.

Avoid getting liquids of any kind on the speaker cone (behind the perforated opening in the side panel).

A warm instrument, taken into a cool, humid environment, may draw moisture into the case. The moisture thus drawn in may create discharge paths on the circuit boards. The instrument should be allowed to dry thoroughly before using.

Mechanical Considerations

Disassembly Procedures

A detailed procedure for disassembly of the instrument and the battery pack may be found in the Maintenance Section of this manual.

Instrument Carrying Handle

The carrying handle of the Type 410 may be moved to any one of 18 positions. The various positions may be utilized for carrying, tilting up or down for better viewing angle or with optional hardware for mounting to other operating room equipment (such as gas equipment or roll-away cart). See Fig. 2-39 through 2-43.

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

This section of the manual contains an electrical description of each circuit in the Type 410. Battery terminal voltages, which are unregulated and are indicated as + and —6.7 volts on all schematics (see First Time Operation, NiCd battery discharge curves), will be referred to as + and — $E_{BATTERY}$. The electron flow convention is followed in this circuit description.

The schematic diagrams at the rear of the manual should be referred to in addition to the illustrations when studying this circuit description. The block diagram shows the relationship of the major circuits.

BLOCK DIAGRAM DESCRIPTION

The desired signal is selected by a three-position INPUT SELECTOR switch and applied to the Vertical Amplifier input stage. The input stage is a differential amplifier, and common-mode signals between ground and the two inputs are rejected. The difference between the two inputs is amplified. Special circuitry is incorporated to ensure that high common-mode rejection ratio is maintained when the electrode source impedance is high and unbalanced. Quick overdrive recovery ($\leq$4 seconds) is possible largely through the elimination of input coupling capacitors. Scan limiter circuits are incorporated in the amplifier stage to reduce recovery time and to limit the vertical information to an area approximately within the screen edges.

The yoke drivers convert the signal voltage to current for the yoke coils. The circuit consists of a push-pull current feedback amplifier; the yoke coils are the feedback elements. About 15 mA is required for one centimeter of deflection.

When the INPUT SELECTOR is in the ECG and AUX positions, the sweep generator and audio circuits are triggered by voltage signals picked off the vertical deflection yoke coil terminals. A full-wave rectifier allows the predominating signal peak to be selected from either terminal and applied to the Trigger Discriminator. The Trigger Discriminator controls the operation of the Trigger Multi, providing switching current activated by the triggering signal.

The Trigger Multi has three operating modes—one monostable and two astable, and provides short-duration pulses for switching the Sweep Multi and gating pulses which activate the Audio Oscillator. When the INPUT SELECTOR is in the ECG and AUX positions, the Trigger Multi normally operates in its monostable mode (one input pulse for each significant signal excursion). In the event of a loss of signal to the Trigger Discriminator, the Discriminator Reset circuit converts the Trigger Multi to an astable (free running) mode of operation after two to four seconds. In the astable mode, the Trigger Multi generates 6 to 10 pulses per second, providing a free running sweep and at the same time providing 6 to 10 notes per second as audible indication of signal loss. When the INPUT SELECTOR is in the EEG position, the audio circuit is disabled and the Trigger Multi is placed in a permanent astable mode.

The Sweep Multi is an electronic switch that turns the Disconnect Diodes off, allowing the Miller Circuit to produce a sawtooth signal. The Sweep Multi is turned off by a pulse from the Trigger Multi to start a sawtooth and turned on to terminate the sawtooth when the output of the Miller Circuit reaches a certain amplitude. Final amplitude is sensed by the sweep-reset diode which injects turn-on current into the Sweep Multi. When the Sweep Multi is turned on, the Miller Circuit resets to form the retrace or falling portion of the sawtooth. A positive-going pulse is passed to the Blanking Amp to blank the CRT during retrace. Following a short stabilization period, the sweep generator circuits are ready to repeat the sequence.

The Miller Circuit is an operational amplifier connected as a gated integrator. The linearly increasing voltage ramp (sawtooth) it produces is passed to the Horizontal Yoke Driver, is converted into a push-pull signal and applied to the horizontal yoke coils to drive the CRT beam across the screen at a constant speed.

A sine wave class C oscillator and transformer produce the voltages necesary, in addition to the battery supply, to operate the Type 410. Regulation of the output voltages is accomplished by applying error voltage (derived by comparing the +17-volt supply to a —11.4-volt reference voltage and amplifying any change (error) in the +17-volt supply) to the oscillator. High voltage for the CRT is produced by a diode and capacitor network that functions as a rectifier/multiplier.

The CRT has a directly heated cathode and is operated at constant beam current. A negative feedback amplifier sets up the biasing conditions of the CRT. A blanking pulse interrupts the beam current and turns the CRT off during sweep retrace.

The battery supply voltages and circuit ground reference for the Type 410 are established by the ten size C rechargeable NiCd cells contained in the power pack. The cells may be recharged by connecting the power cord between the power pack and line voltage. The charging circuit is regulated to ensure a constant charging current.

INPUT SYSTEM

Input Switches

Table 3-1 shows the relationship of circuit functions in the three positions of SW25, INPUT SELECTOR. The physiological signal to be monitored is connected from the Patient Cable INPUT connector to the Vertical Amplifier input stage

by the INPUT SELECTOR. Only when the INPUT SELECTOR is in the AUX position are the + and — battery voltages ($E_{BATTERY}$) supplied through the Patient Cable to the transducer. R31 and R33 limit the current through the Patient Cable to about 100 mA under short-circuit conditions to eliminate unnecessary blowing of the battery-pack fuses. Battery is disconnected from all loading circuits when SW280, SWEEP SPEED, is placed in the POWER OFF position.

The INPUT SELECTOR provides isolated switch contacts, via the OUTPUT connector, which are closed in the ECG and AUX positions, and open in EEG. This switch logic can be used to enable or disable external devices which use the vertical- and trigger-output signals of the Type 410. This permits, for example, separation of cardiac-related signals from the non-cardiac related signals. In the Gain-Selection Amplifier stage, the gain is controlled by switching different resistors between the collectors to shunt the collector load.

SW15, ECG LEAD SELECTOR, permits the selection of any of seven commonly used ECG leads. In leads aV_R, aV_L, aV_F and V, the correct combination of resistors is selected from the resistor network composed of R11, R12, R14, R15, R16, R17 and R19. These resistors have sufficiently high values to minimize the imbalance of electrode contact impedance. See Fig. 3-1.

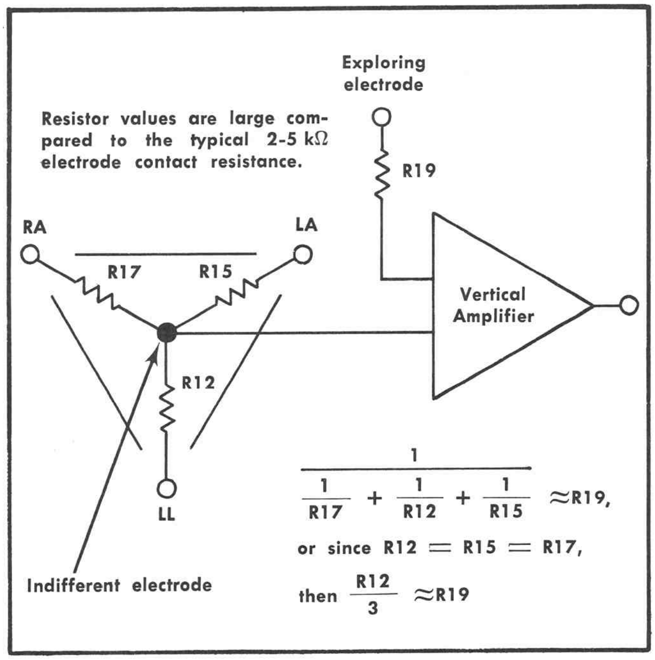


Fig. 3-1. Minimizing the imbalance of impedance in the unipolar ECG lead configurations, using Lead V as an example.

VERTICAL AMPLIFIER

Input Overdrive Protection

Because the Vertical Amplifier is subject to receiving large transient signals (such as cautery and defibrillator pulses), networks have been provided to protect the input circuit components. Back-to-back Field Effect Diodes (FEDs) D107-D108 and D207-D208 are in series with the input FET gates as shown in Fig. 3-2. These diodes limit current in either direction to about 270 μA. These diodes would likewise limit the current which could reach the patient in the event of a failure within the instrument, but since destructive input signals are blocked, by far the most significant cause of internal failures has been eliminated. In addition, current-limiting resistors R101 and R201 and overload neons B103, B106 and B206 effectively remove transients that may exceed the 100-volt breakdown of the FEDs.

Differential Amplifier

The input stage of the Vertical Amplifier, shown in simplified form in Fig. 3-3, is a differential amplifier. The most important characteristics of the first stage include an approximate 15 times amplification of the voltage differences between the two inputs, and ideally, the total rejection of signals common to both inputs with respect to circuit ground. The latter attribute is called common-mode rejection. Com-

TABLE 3-1

FUNCTION	DEFLECTION FACTOR	TRIGGER MULTIVIBRATOR	AUDIO	TRANSDUCER POWER	Isolated Switch Contacts
EEG	10 mm/50 μV[1] (50 μV/cm)	Astable (free running sweep)	No	No	Open
ECG	20 mm/mV[1] (0.5 mV/cm)	Monostable (triggered sweep. Becomes astable after a asignal loss.)	Yes	No	Closed
AUX	2 mm/mV[1] (5 mV/cm)	Monostable (triggered sweep. Becomes astable after a signal loss.)	Yes	Yes	Closed

[1]**With the VERTICAL SIZE control in the CAL detent. See Page 1-1, CHARACTERISTICS.**

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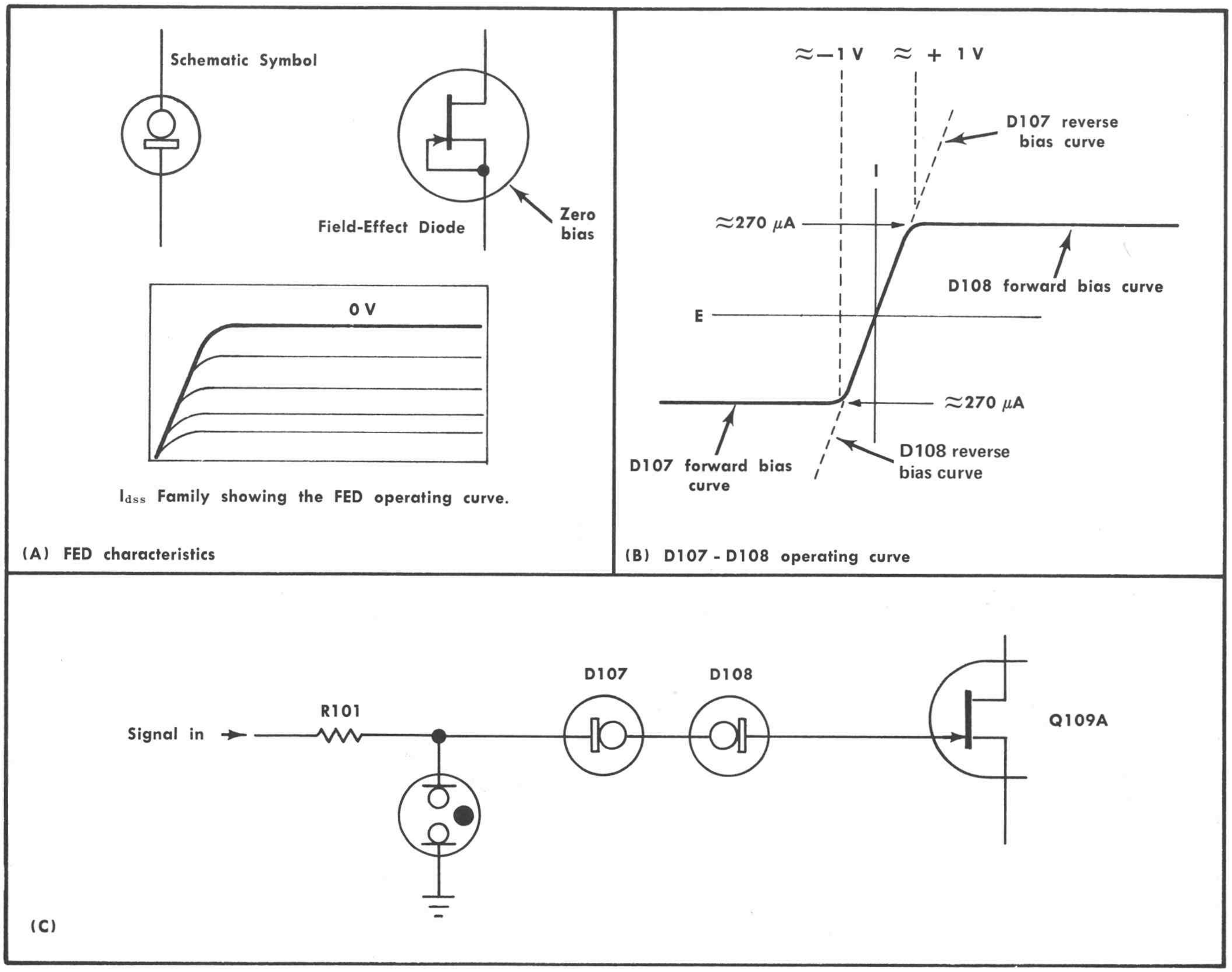


Fig. 3-2. Input overdrive protection network.

mon-mode rejection ratio (CMRR), described in Section 1 of this manual, may be defined as the ratio of the common-mode voltage required to produce a certain display amplitude, to the differential voltage required to produce the same display amplitude.

The input signal is DC-coupled from the INPUT SELECTOR to the gates of Q109A and Q109B. The absence of AC-coupling capacitors enables the input to recover quickly after a large transient pulse and also helps to prevent a loss of common-mode rejection by reducing the effects of unbalanced capacitive reactance. The differential input resistance of the amplifier is the total of R107 and R207 when the INPUT SELECTOR is in the AUX position. R107 and R207 are paralleled by R21 (Connectors & Switching diagram) when the INPUT SELECTOR is in EEG, and parallel by R23 in ECG. R105 provides the leakage-current path for the input FET gates and establishes the zero DC reference on the gates.

Q109A and Q119 are connected in a cascode configuration on the + input side and Q109B and Q219 are connected in cascode in the — input side. Combined, the two sides operate at an essentially constant current that is ensured by the high impedance current source, Q215. A small amount of current from Q215 passes through R114 to be absorbed by Q110. The voltage drop across R114 is constant because of the constant current operation of Q110; therefore, the Q119-Q219 base voltages are held constant with respect to the FET sources. The high impedance constant current source and constant Q109A-Q109B drain-to-source voltage will be discussed in full detail in later paragraphs.

The dynamic range of the amplifier is limited to gate voltage differences of about 100 millivolts. This limit does not pertain to the gate voltages with respect to circuit ground, but only with respect to one another. The signal applied to the FET gates causes the balance of current through the two sides to shift, producing the difference signal across R119 and R219. If, for example, the input signal is such that the gate of Q109A is more positive than the gate of Q109B, current is increased through Q109A and descreased by the same amount through Q109B. This results in a push-pull output, negative-going at Q119 collector and positive-going at Q219 collector. Since the transconductance of Q109A and Q109B can vary from one FET to another, the gain of the differential amplifier can be corrected by changing the variable load impedance on the collectors of Q119 and Q219. The gain of this stage is set to ≈15 by R124, GAIN.

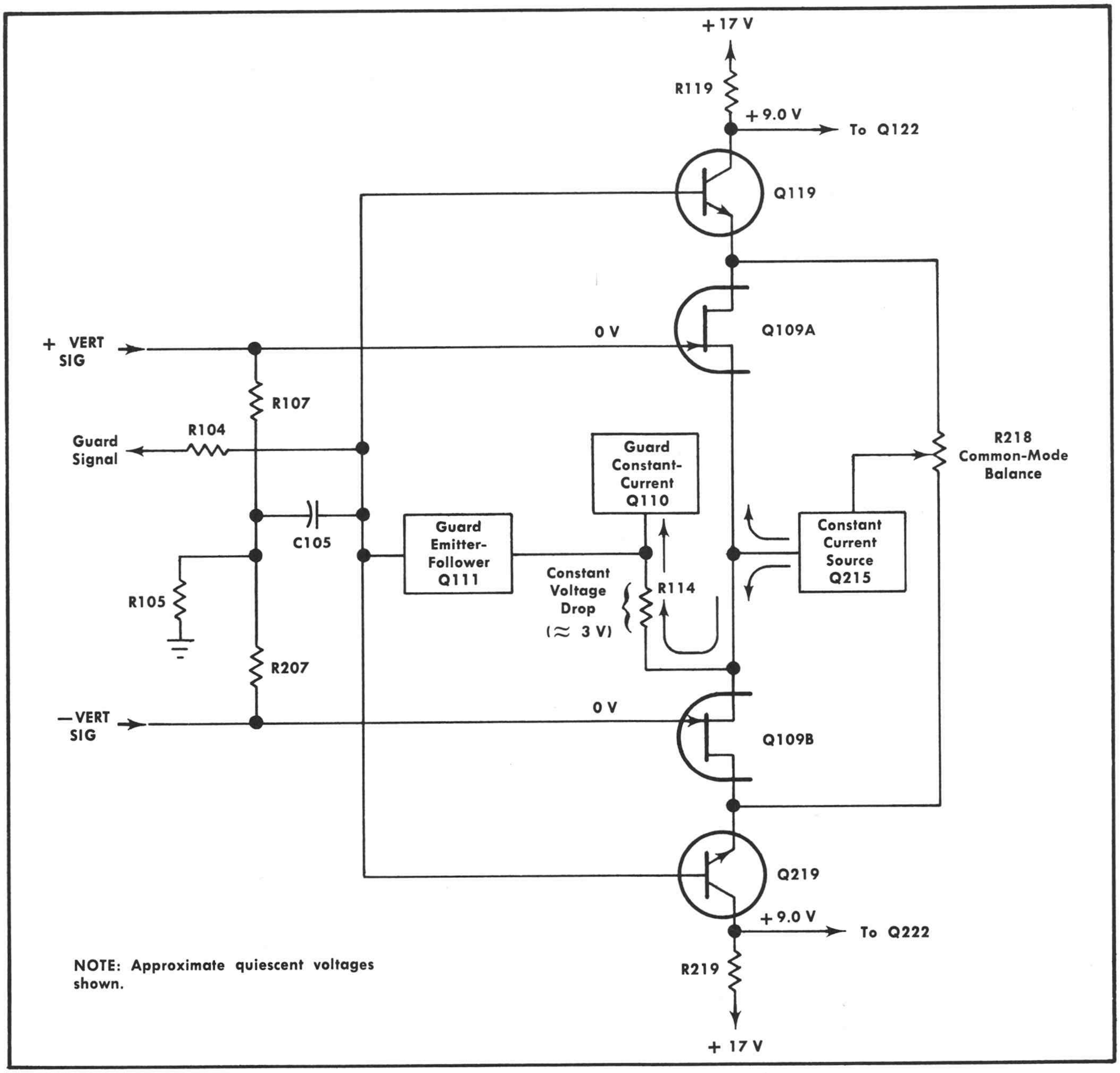


Fig. 3-3. Simplified diagram of the Vertical Amplifier input stage.

The degree of common-mode rejection exhibited by the differential amplifier will depend primarily on the high impedance current source and the constant drain-to-source voltage maintained on the FETs during common-mode signal. Common-mode signal amplitudes (signals of equal amplitude applied in phase to both inputs) up to + and — 3 volts peak at the gates will produce essentially no change in the division of the common-source current between the FETs. The common-source voltage will, however, follow the common-mode signal in the manner of a single cathode follower. This voltage variation causes an essentially equal variation at the Q119-Q219 bases so that the Q109A and Q109B drain-to-source voltages remain constant. This virtually eliminates any change in current division between the FETs due to differences in their parameters.

Since the impedance of the Q109A-Q109B common-source-current source is finite, a small but significant change in the total common-source current will occur. The additional current probably will not divide between the FETs in the same proportions as the basic current because of differences in transconductance. The current division is corrected by proper setting of R218, COM MODE BAL, so that the current is inserted or removed (depending on instantaneous common-mode polarity) in the correct portions at the emitter of Q119 and Q219.

Fig. 3-4 shows the differential amplifier input stage redrawn to illustrate the impedance relationship that exist within the circuit.

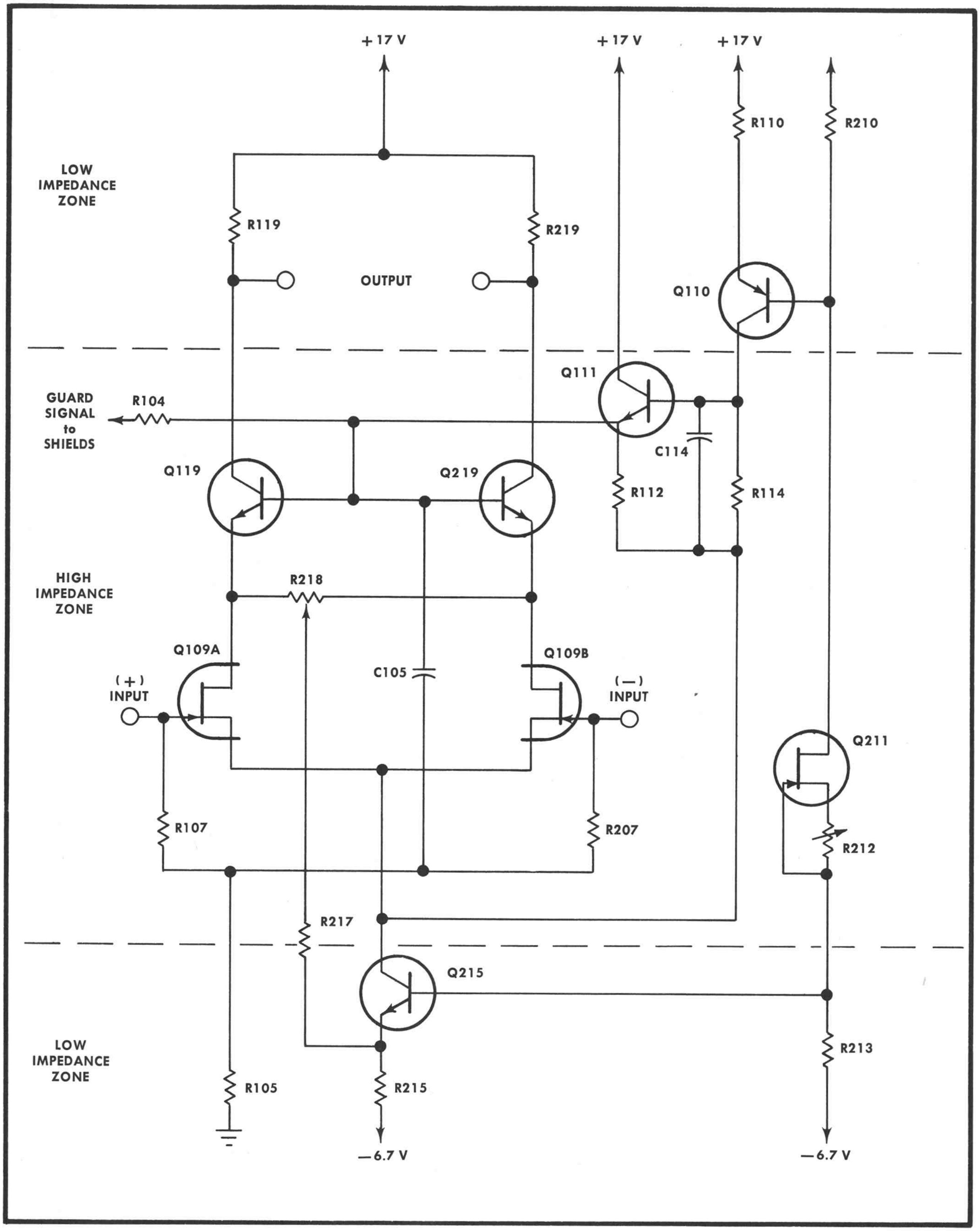


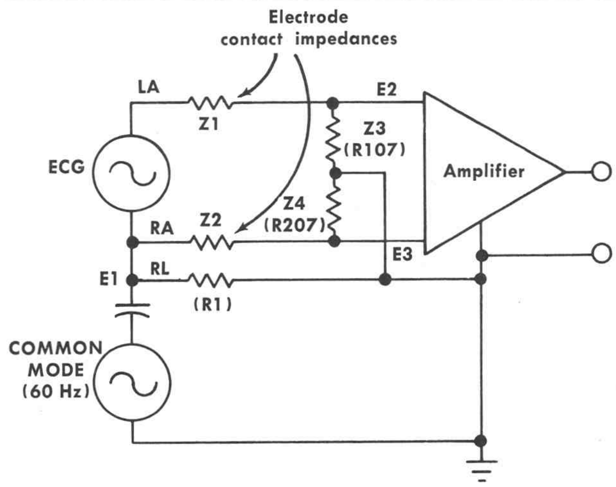
Fig. 3-4. Partial diagram showing differential amplifier impedance relationships.

Input Guarding System

It is important that the high common-mode rejection ratio of the differential amplifier is maintained when the electrode source impedance is high and unbalanced. This is accomplished by "guarding" the Patient Cable and portions of the input circuitry with the common-mode signal. Input guarding is a means of connecting the input circuitry so as to prevent any common-mode signal from causing current change in the input. Thus, in an ideal guarded input, differences of source impedance do not cause conversion of the common-mode signal into a differential signal.

From the example shown in Fig. 3-5, it can be seen that the amplifier shunt impedance to ground (Z_3 and Z_4) should be as high as possible while the source impedance difference (Z_2-Z_1) should be as low as possible.

The low-frequency common-mode signal is applied to the input gates of Q109A and Q109B, and because total current change is strongly suppressed by Q215, the signal is repro-



If $\text{CMRR} = \frac{E_1}{|E_2 - E_3|}$, $E_2 = \frac{Z_3E_1}{Z_1Z_3}$,

$E_3 = \frac{Z_4E_1}{Z_2 + Z_4}$, and $Z_3 = Z_4$, then by substitution

$$(1)\quad \text{CMRR} = \frac{E_1}{\left|\frac{Z_3E_1}{Z_1 + Z_3} - \frac{Z_3E_1}{Z_2 + Z_3}\right|},$$

$$(2)\quad = \frac{E_1\,(Z_1 + Z_3)\,(Z_2 + Z_3)}{Z_3E_1\,|\,(Z_2 + Z_3) - (Z_1 + Z_3)\,|},$$

$$(3)\quad = \frac{(Z_1 + Z_3)\,(Z_2 + Z_3)}{Z_3\,|\,Z_2 - Z_1\,|}.$$

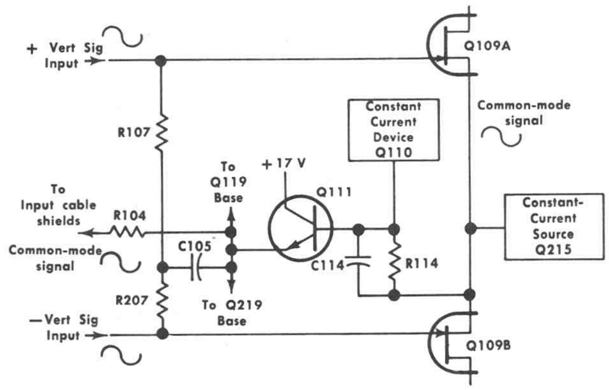
Where $Z_3 >> Z_1$ and $Z_3 >> Z_2$, then $\text{CMRR} \simeq \frac{Z_3}{|\,Z_2 - Z_1\,|}$.

(Without a guard circuit)

By assigning typical values $Z_1 = 1\ \text{k}\Omega$, $Z_2 = 5\ \text{k}\Omega$, and $Z_3 = 10\ \text{M}\Omega$ and applying these values to the CMRR equation, a ratio of 2500:1 is derived. If the common-mode signal amplitude is one volt of a 60 Hz sinewave, a 0.4 mV differential signal results. Since ECG signals are typically about one millivolt peak-to-peak, the 60 Hz interference has a magnitude 40% that of the ECG signal.

If, for example, the values of Z_3 and Z_4 could be effectively increased by a factor of 200, the CMRR would be 500,000:1, and the 60 Hz interference would be insignificant.

Fig. 3-5. Calculating common-mode rejection ratio (CMRR) of the passive input circuitry.



Assume that 99.95% of a 60 Hz common-mode signal applied to the input FET gates is passed through the guard circuit to the R107-R207 juncture. Thus, a 1-volt common mode signal applied to the inputs produces a 999.5 mV in-phase signal at R107-R207 juncture. With only a 0.5 mV change across R107 and R207 the effect is an apparent multiplication of R107 and R207 values, as shown by:

$$(1)\quad R_{in} = \frac{\Delta\ E_{in}}{\Delta\ I_{in}},\ \text{where}\ \Delta\ E_{in} = 1\ \text{Volt and}$$

$$\Delta\ I_{in} = \frac{E_{in} - E_{guard}}{R107},$$

$$= \frac{1\ \text{Volt} - 999.5\ \text{mV}}{R107},$$

$$= \frac{0.5\ \text{mV}}{R107}$$

$$(2)\quad R_{in} = \frac{1\ \text{Volt}}{\frac{0.5\ \text{mV}}{R107}}$$

$$(3)\quad = \frac{1\ \text{Volt} \times R107}{0.5 \times 10^{-3}\text{Volt}}$$

$$(4)\quad = R107 \times 2 \times 10^3$$

For example, applying a value of 10 MΩ to R107 and R207 results in an apparent input impedance of 20,000 MΩ for each side. The value realized in practice is substantially lower, because R107 and R207 are paralleled by many resistive and capacitive leakage paths which cannot be guarded.

Fig. 3-6. Calculating apparent input impedance to common-mode signal.

duced at the FET sources with almost no loss in amplitude. The signal is then applied through C114-R114 to the base of emitter-follower Q111. Q111 serves as an isolation stage to maintain the differential amplifier constant current operation by minimizing loading of the FET sources. The common-mode signal is coupled from the emitter of Q111 to R107-R207 through C105. Since C105 passes only the AC portion of the signal, the DC level at the emitter of Q111 is isolated from the ground reference point at the R107-R207 juncture.

Assume that 99.95% of a 60-hertz common-mode signal applied to the input FET gates is passed through the guard circuit and coupled through C105 to the R107-R207 juncture. Since a voltage change of only 5 parts in 10,000 is developed across R107 and R207, the effect is an apparent 2,000 times multiplication of R107 and R207 values. See Fig. 3-6.

The desirable practice of using shielded input cables of a reasonable length results in a shunt capacitance to ground of perhaps several hundred picofarads. This capacitance, if paralleled with the input resistance, would reduce the total input impedance and CMRR. To reduce this effect in the Type 410, the guard signal is applied to the shields surrounding the input cables and switches to effectively decrease the input common-mode shunt capacitance.

Constant Current High Impedance Source

The collector of Q215 is a constant-current high impedance source for the differential amplifier input stage and for the guard circuit. See Fig. 3-7. The voltage developed across R215 establishes about 800 μA of constant current through Q215. This current is split at Q215 collector, with about 350 μA through each side of the differential amplifier and about 100 μA into the guard circuit. Constant current of about 45 μA for setting the voltage drop across R114 is establised through Q110 by the voltage developed across R110, and the remaining 55 μA flows through R112 and the emitter follower, Q111.

The voltage divider composed of R210, Q211, R212 and R213, between the regulated +17-volt supply and the $-E_{BATTERY}$ supply establishes the DC levels on the bases of Q110 and Q215. Q211 is an active high-impedance element which maintains an essentially constant R210-R213 current even though the battery voltage connected to R213 varies with state of charge. The amount of current through Q211 is established by the bias level set by R212, COLLECTOR VOLTS. Since the R213 current is constant, thereby producing a constant voltage drop across R213, the Q215 base and emitter

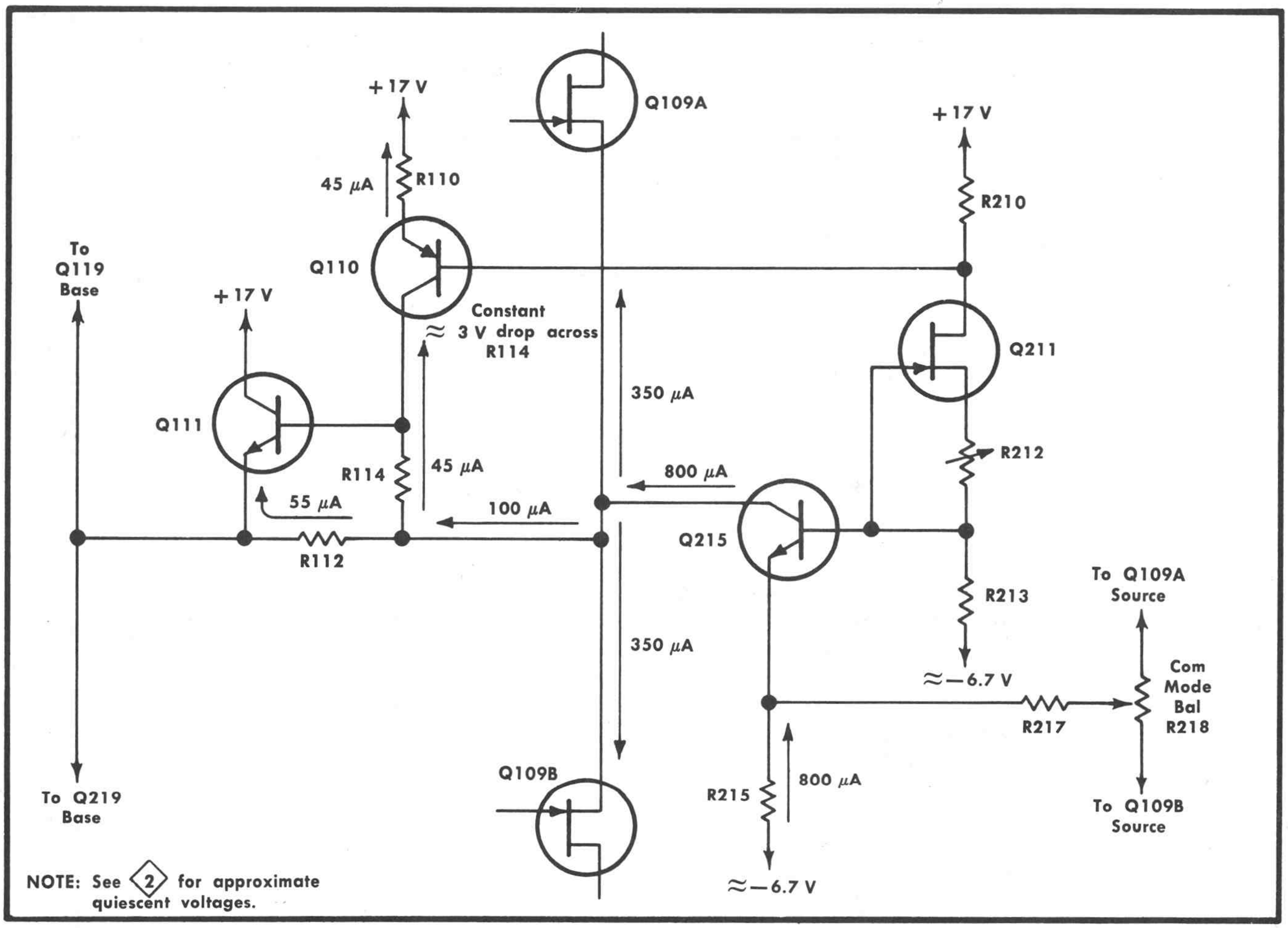


Fig. 3-7. Partial diagram showing constant current high impedance source and guard circuit.

follow the variations of the $-E_{BATTERY}$ supply. Thus, both ends of R215 follow the variations and the voltage drop across R215 is constant, maintaining the desired constant current in Q215. In the same manner, the constant R210 current maintains constant current in Q110.

Q109A-Q109B Constant Drain-to-Source Voltage

Establishing constant drain-to-source voltage for Q109A and Q109B is a function of the guard circuit. The constant current through R114 maintains a constant voltage drop across R14 of about 3.5 volts, elevating the base of Q111 above the Q109A-Q109B mean source voltage by this amount. Refer to Fig. 3-3. About one-half volt is dropped across the Q111 base-emitter junction and another one-half volt is dropped across the Q119-Q219 base emitter punctions, setting the Q109A-Q109B drain voltage at about 2.5 volts with respect to the common-source potential. Because of constant current through R114, a unit of voltage change at the FET sources results in a unit of voltage change on the FET drains through R114, Q111, and Q19-Q219. Therefore, the drain-to-source voltage of Q109A and Q109B will remain nearly constant under common-mode signal conditions, aiding in maintaining the high degree of CMRR previously discussed.

Gain-Selection Amplifier Stage

Q122, Q222 and their associated circuit components form a push-pull amplifier (Fig. 3-8). DC current for each side of the amplifier is set by R127 and R227 in the emitter circuits. With the two sides of the circuit balanced, no current flows through R126. The push-pull signal applied to the bases of Q122 and Q222 is developed across the parallel combination of R126 and R127-R227. This causes current through the two transistors to change by equal, but opposite amounts. This results in an inverted and amplified push-pull signal at Q122-Q222 collectors. D123 and D223 prevent base-to-emitter reverse breakdown under input overdrive conditions.

Because the physiological signals to be monitored are of widely different voltage ranges, it is necessary to adjust the gain of the Vertical Amplifier to correspond to each input signal. This gain selection is a function of the INPUT SELECTOR and is accomplished by changing the shunt load impedance in the collector circuits of Q122 and Q222. When the INPUT SELECTOR is in EEG, R121-R134 and R221-R234 provide the collector load impedance. These basic loads are shunted by R131 in ECG and R132 in AUX. Each selection changes the gain of the stage by a factor of 10, so that the overall gain of the first two Vertical Amplifier stages is $\approx$100 in EEG, $\approx$10 in ECG, and $\approx$1 in AUX.

Capacitor C129 is connected between the colector of Q122 and Q222 to limit the bandwidth under EEG signal conditions to about 100 hertz. Because the load impedance changes by a factor of 10 with each gain selection, bandwidth also changes and is about 1 kHz in ECG and 10 kHz in AUX. Maximum bandwidth under ECG and AUX signal conditions is limited to about 250 hertz in the following amplifier stage.

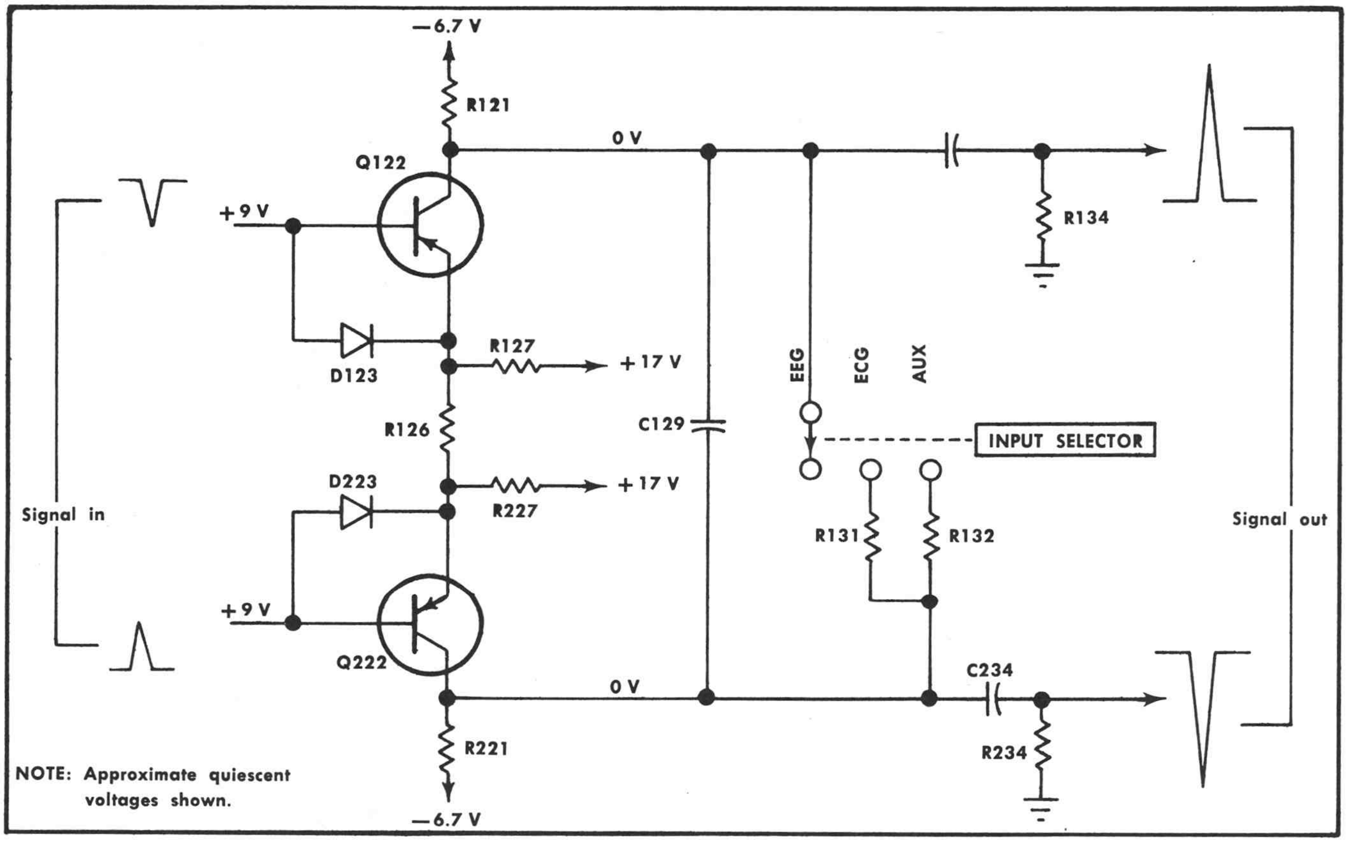


Fig. 3-8. Partial diagram showing gain selection stage.

Ⓐ

Output Amplifier Stage

The output amplifier, shown in simplified block diagram form in Fig. 3-9, performs the final signal amplification to be applied to the yoke driver circuits. Special circuitry is incorporated to insure quick overdrive recovery and to limit the CRT scan to aproximately within the screen edges. Controls for vertical positioning and changing the size of vertical display are also incorporated.

The signal from the Q122-Q222 collectors is AC-coupled through C134 and C234 to the gates of Q137A and Q137B. R121-C134-R134 on one side and R221-C234-R234 on the other side set the low frequency —3 dB point at slightly less than 0.1 hertz. R134 and R234 also provide the leakage current path for the FET gates, establishing zero DC reference. D134-D135 and D235-D236 limit the swing of the signal applied to the FETs and also provide a discharge path for C134 and C234 in the event of an overdrive signal.

The sources of Q137A and Q137B are returned through R137 and R237 to the high impedance current source, Q151. Refer to Fig. 3-10. The drain current supply for Q137A and Q137B is connected through the wiper arm of R139, VERT SIZE BAL, to R136 and R236. The DC voltage levels at Q137A-Q137B drains are balanced by adjusting of R136 to minimize trace shift when R249, VERTICAL SIZE control, is rotated. R141 and C141 connected between the drains of Q137A and Q137B set the gain of this stage and limit the bandwidth to about 250 hertz. The signal is inverted and amplified by Q137A-Q137B and passed to the bases of Q145 and Q245.

Q145-Q154, Q245-Q254, and their associated circuitry form a push-pull non-inverting negative-feedback amplifier, having a high input impedance and a low output impedance. See Fig. 3-11. The voltages across R156 and R256 set the quiescent currents through Q145 and Q245. With the amplifier balanced, there is no current through R148, R249 and R248. R149, VERTICAL POSITION, provides a means of diverting current from one side of the amplifier to the other through either R147 or R247 to vertically position the display.

The emitters of Q154 and Q254 are clamped at about +12 volts by Zener diode D158. (The typical drop across the Zener diode is slightly less than the rated value due to the low current at which it is operated.) With R149 electrically centered,

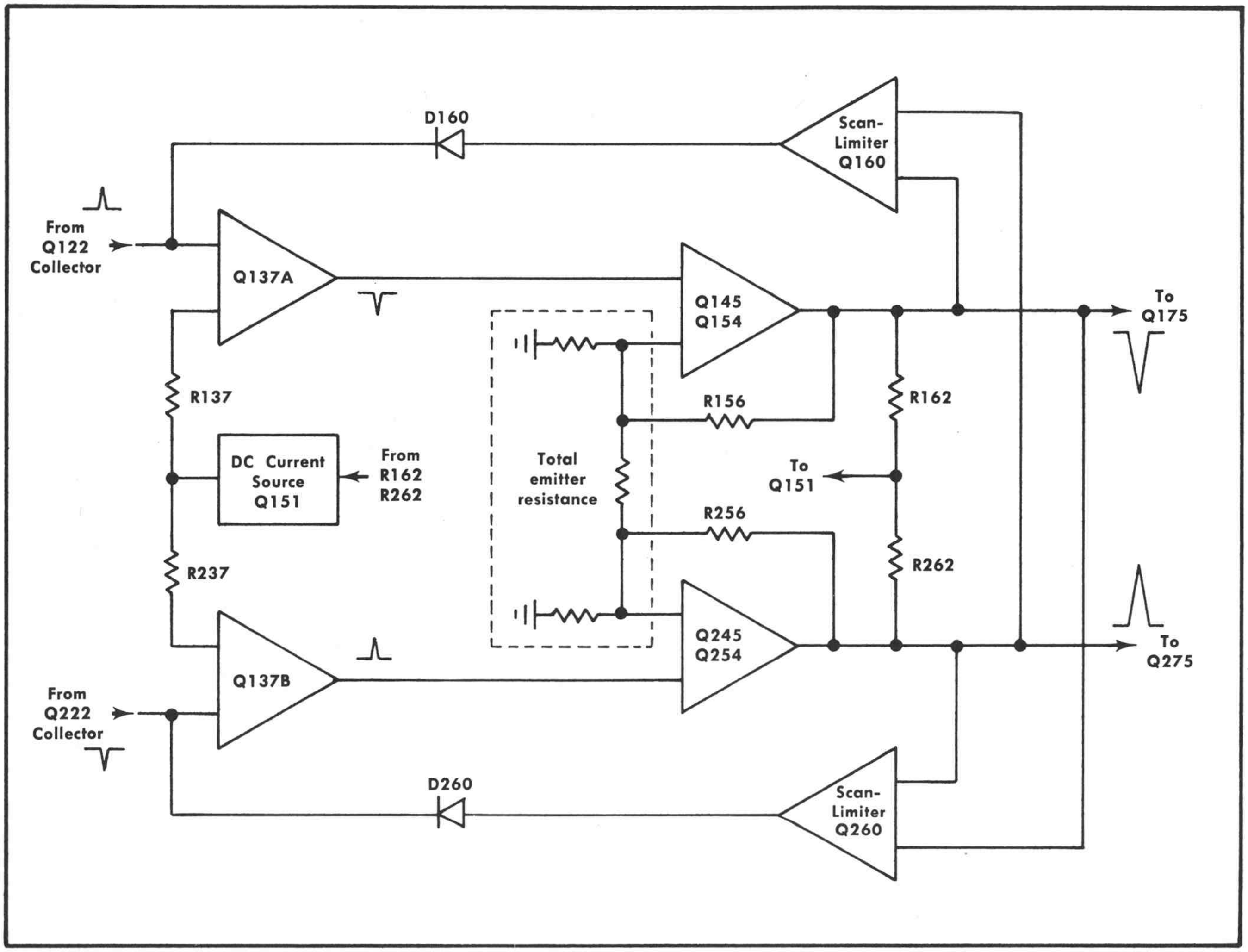


Fig. 3-9. Simplified block diagram of output amplifier.

the collectors of Q154 and Q254 are balanced, each having a potential of about +0.6 volts. This voltage is established by common-mode negative feedback through R162 and R262 by th base-to-emitter voltage of Q151 and regulated at this level by Q151, which supplies current for Q137A-Q137B and thus affects the DC voltage levels throughout the output amplifier. Regulating the Q154-Q254 collectors at about +0.6 volts allows the Yoke Driver circuit to make optimum use of the + and $-E_{BATTERY}$ supplies. (This will be discussed in further detail in the Yoke Driver circuit description.)

The non-inverting amplifier stage produces a push-pull output signal at the colectors of Q154 and Q254 that is in phase with the push-pull signal applied to the bases of Q145 and Q245. R156 and R256 provide a negative feedback path from the output collectors to the emitters of Q145 and Q245. Voltage gain of the non-inverting amplifier stage is determined by R156, R256, and the equivalent resistance between the emitters of Q145 and Q245. Form the formula $A \approx \frac{R_o + R_i}{R_i}$, where R_o = R156 + R256 and R_i = R148 + R249 + R248 in parallel with R147 + R149 + R247, it becomes apparent that changing the value of R_i results in a change of voltage gain. This is the function of R249, VERTICAL SIZE.

Turning the control from its detent (CAL) position to the extreme counterclockwise position reduces display size to ⅓ or less, while turning VERTICAL SIZE fully clockwise from CAL results in a 3-times increase in display size.

Scan Limiters

The scan-limiter circuits have been incorporated to enhance quick signal overdrive recovery. They consist of Q160, R160 and D160 on one side and Q260, R260 and D260 on the other side. Q160 and Q260 are connected such that sufficient imbalance of Q154-Q254 collector voltages causes either Q160 or Q260 to turn on. Refer to Fig. 3-12.

For example, assume that an excessive push-pull signal, positive-going at Q137A gate and negative-going at Q137B gate, results in driving Q154 collector negative and Q254 collector positive with sufficient voltage difference to turn Q260 on (a condition which can also be arrived at by turning R149, VERTICAL POSITION, to its clockwise extreme. Turning R149 to its counterclockwise extreme causes Q160 to turn on). The current through Q260 pulls its collector positive, turning on D260. Q137B gate, which had started negative with the overdrive signal, is pulled slightly positive by the conduction of D260. As Q137A gate rises positive with the overdrive signal, D135 turns on and clamps Q137A gate at about 0.6 volts. In addition, the inputs of the Yoke Drivers; that is, the bases of Q175 and Q275, are clamped at the turn-in voltage levels of Q260 until the output amplifier recovers, and the trace cannot be deflected far beyond the top edge of the CRT screen.

When the overdrive signal terminates, the gate of Q137A is no longer clamped at +0.6 volts by D135. Q260 and D260

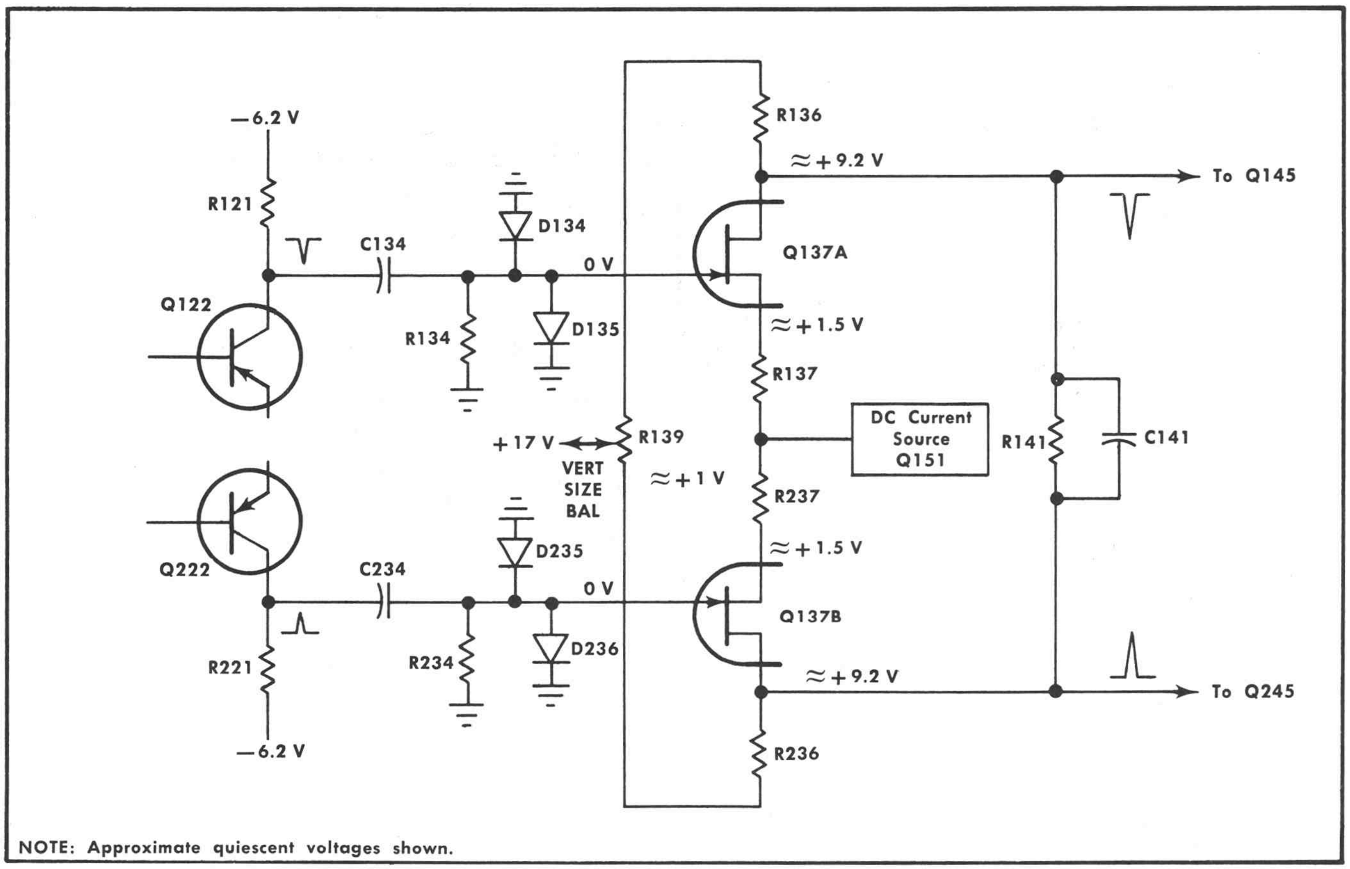


Fig. 3-10. Partial diagram showing AC-coupling stage.

turn off as the collectors of Q154 and Q254 reverse polarity and at the same time, Q160 and D160 turn on. The gate of Q137A is held about a half volt positive by the conduction of D160. When C234 recovers enough to allow D236 to turn off, the FETs can operate differentially as their gates drift back to their zero DC common-mode references.

Yoke Driver Circuit

The Yoke Driver circuit (Fig. 3-13) converts the signal voltage to a driving current for the vertical yoke coils. Q175-Q180, Q275-Q280, and their associated circuit components form a push-pull non-inverting current-feedback amplifier. The yoke current sources are Q186 and Q286, and current is fed back to the Q175-Q275 emitter circuit through the yoke coils, L555A and L555B. Positive and negative triggering information is picked off the yoke input terminals and passed to the Trigger Discriminator circuit.

The yoke coils require a current of about 15 mA for a vertical deflection of 1 centimeter on the CRT screen. If under quiescent conditions the bases of Q175 and Q275 are balanced by the VERTICAL POSITION control, the voltage developed across the parallel combination of R177 and R178 is zero, and there is no yoke current. If the voltages on the bases of Q175 and Q275 were each changed in opposite polarity by 0.05 volts, then 0.1 volt would be developed

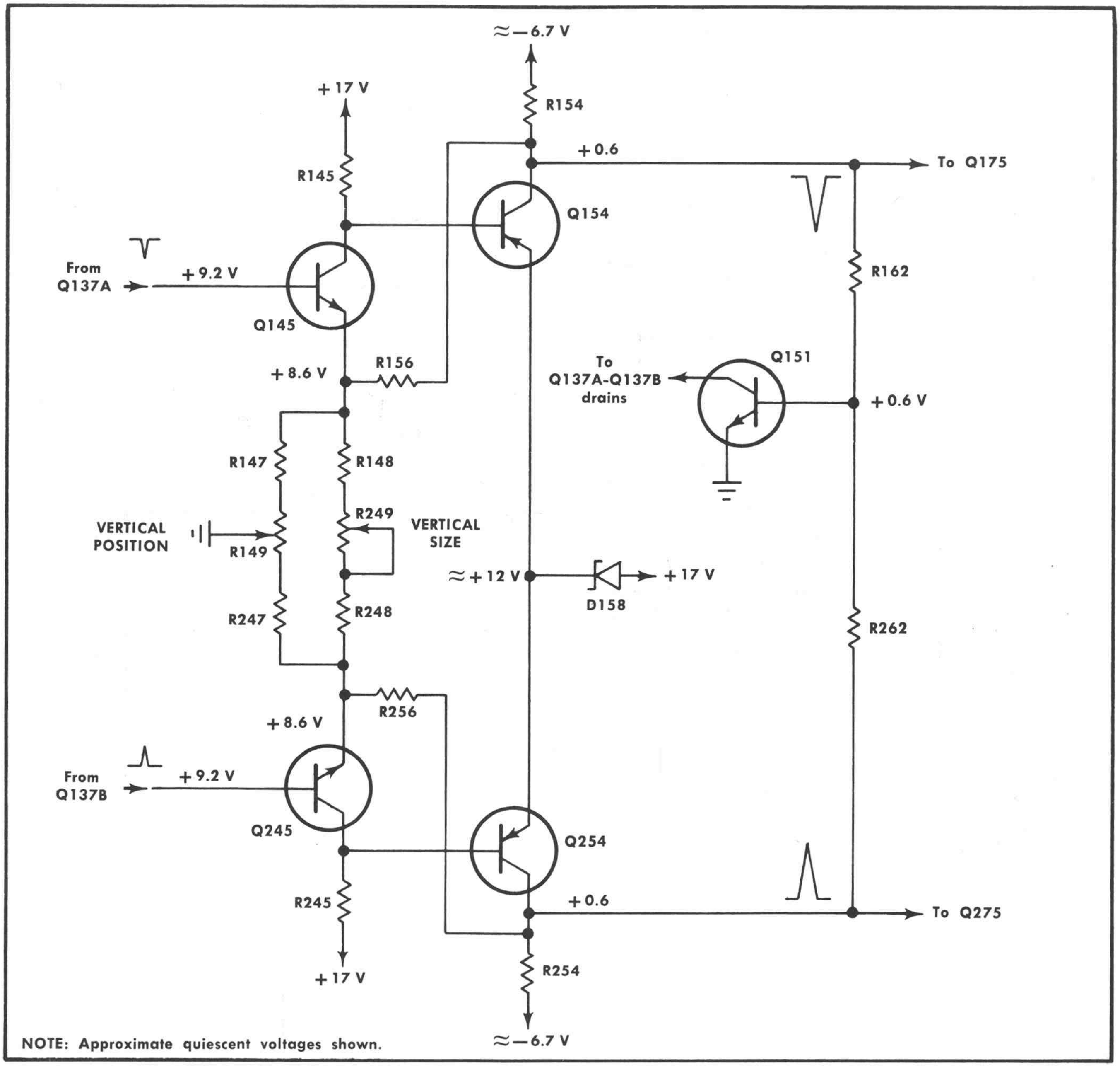


Fig. 3-11. Partial diagram showing non-inverting amplifier stage.

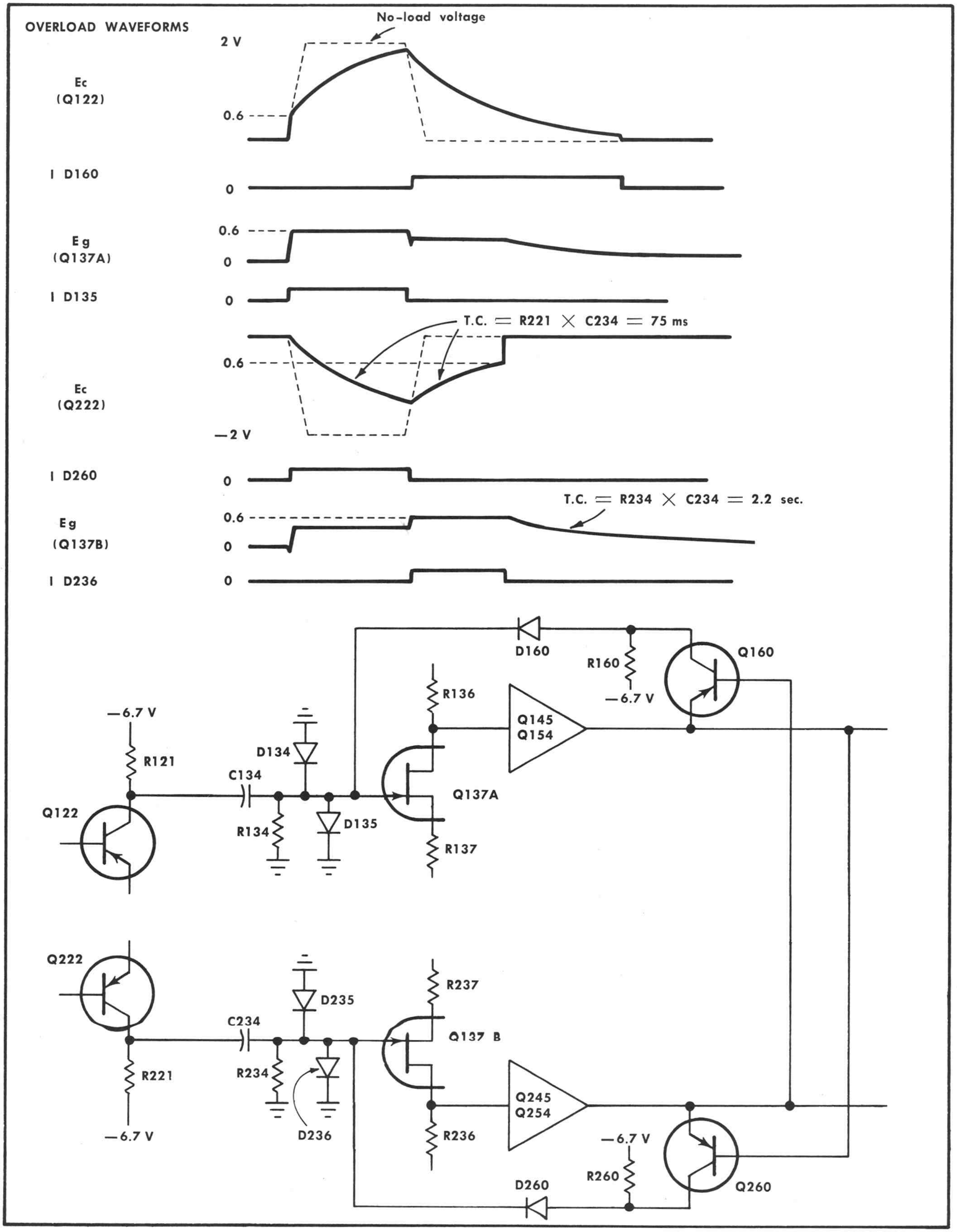


Fig. 3-12. Partial diagram showing operation of scan limiters under overdrive conditions.

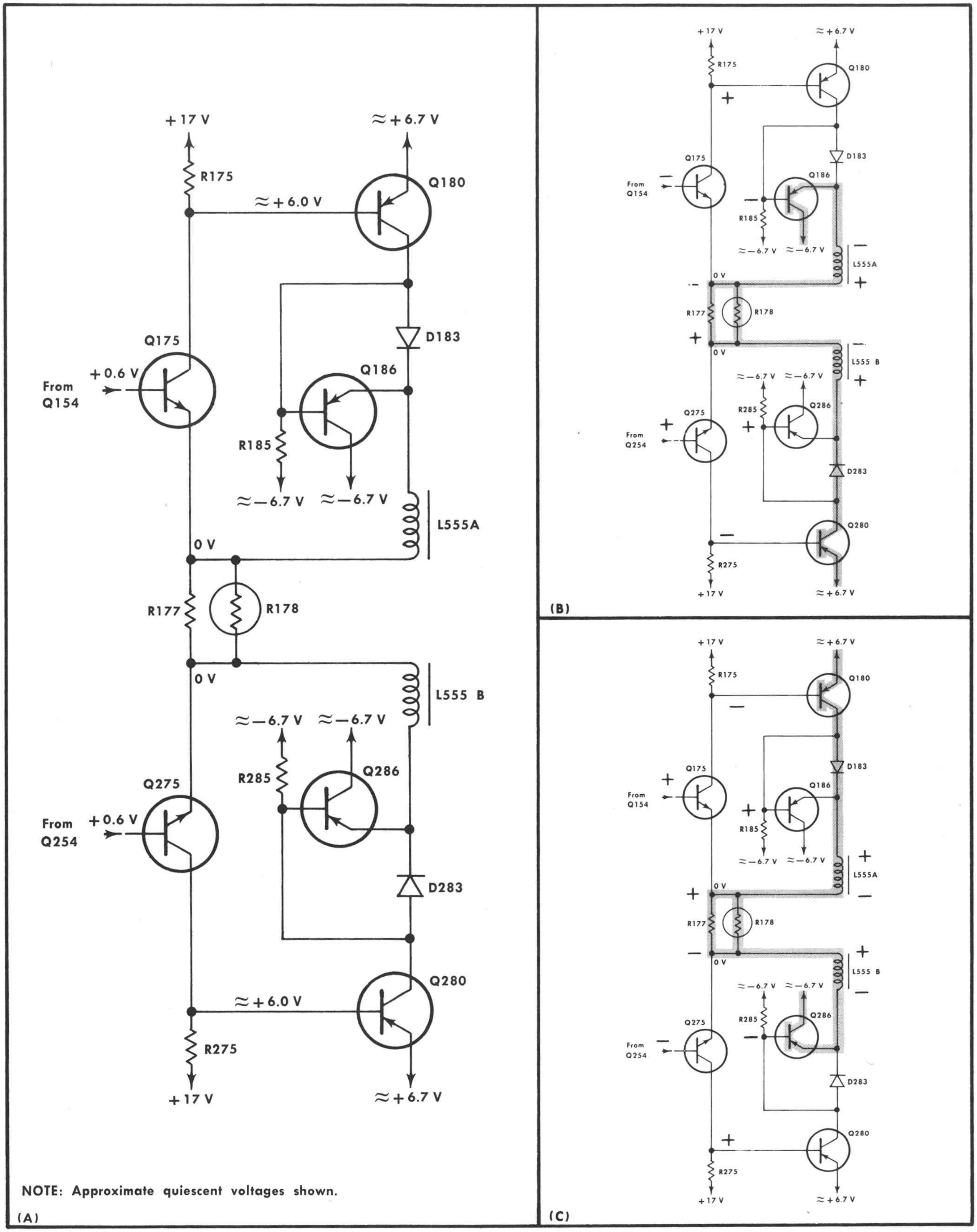


Fig. 3-13. (A) Partial diagram showing vertical yoke driver circuit; (B) Yoke current path for upward (+) deflection; (C) Yoke current path for downward (—) deflection.

across R177-R178, producing a current of about 15 mA through the yoke coils. Therefore, yoke current is equal to the input voltage sensitivity of the yoke driver is ≈0.1 volt per centimeter. The maximum voltage developed across R177-R178, limited to about 0.4 volts by the scan-limiting transistors Q160 and Q260, produces full-scale deflection of about 60 mA through the yoke coils.

Assume that a push-pull signal is applied to the yoke driver circuit, negative-going by 0.1 volt at Q175 base and positive-going by 0.1 volt at Q275 base. The signal is developed across R177-R178, causing current through Q175 to decrease slightly and current through Q275 to increase slightly. Very little current change is exhibited by Q175 and Q275 because of current feedback. The collector potential of Q275 rises, causing a decrease of current through Q180 and at the same time, the collector potential of Q275 falls, causing current through Q280 to increase. When current through Q180 decreases, current is diverted into Q186 base. When Q280 current increases, its collector potential goes positive, applying reverse bias to the base-emitter junction of Q286 and turning D283 on. Refer to Fig. 3-13B. The 0.2 volts developed across R177-R178 establishes a current of about 30 mA, which is drawn through Q186 and L555A from the $-E_{BATTERY}$ supply and passed through L555B, D283 and Q280 to the $+E_{BATTERY}$ supply. If a push-pull signal opposite in polarity to the one just described is applied to the bases of Q175 and Q275, then Q186 is turned off and the current path is from the $-E_{BATTERY}$ supply through Q286, L555B, R177-R178, L555A, D183 and Q180 to the $+E_{BATTERY}$ supply (Fig. 3-13C).

D180 and D280, connected across the base-emitter junction of Q180 and Q280, prevent junction breakdown under extreme reverse-bias conditions. Then resistor R178 compensates for the negative temperature coefficient of the amplifier. A linearizing network consisting of R170, R171, R172, R173, D171, and D172 compensates for the non-linear yoke deflection characteristics.

HORIZONTAL AND AUDIO CIRCUITS

Trigger Multivibrator

Q320, Q330, and their associated circuit components form the Trigger Multivibrator. This circuit provides a positive pulse for gating the Audio circuit and a negative pulse for triggering the sweep generator circuits. In addition, the positive pulse is passed through an emitter follower to the OUTPUT connector.

The Trigger Multivibrator has three operating modes; one monostable and two astable. With the INPUT SELECTOR in the ECG and AUX positions and a heart-related signal applied to the Type 410, this circuit operates as a monostable multivibrator and the output is a pulse for each cycle of signal. In the event of a signal loss, the Trigger Multivibrator reverts to an astable mode to free run the sweep and to produce, through the Audio circuit, 6 to 10 notes per second as an alarm. In the EEG position of the INPUT SELECTOR, the Trigger Multivibrator is placed in a permanent astable mode to free run the sweep and the Audio circuit is locked out.

The first of the three multivibrator modes to be discussed is the astable mode which exists with the INPUT SELECTOR set to EEG. Base current for Q320 is supplied through R319 and D319 from the $-E_{BATTERY}$ supply as shown in Fig. 3-14A. Base current for Q330 is supplied through R329 and D329 from circuit ground. Assuming conditions are such that Q320 is turning on, current into Q320 base causes the transistor to saturate. The collector of Q320 rises rapidly from about −6.7 volts to about +6.5 volts. Current through R329 is diverted from Q330 base and into C329 as the capacitor begins to charge to its new level. With current diverted from its base, Q330 turns off and its collector potential falls rapidly to about −6.7 volts. After an RC-controlled time of about 130 milliseconds, the votage across R329 decays to about +5.5 volts as current into C329 diminishes. Q330 becomes forward biased and conducts, its collector stepping from about −6.7 volts to about +6.5 volts. The potential on the base of Q230 is suddenly changed and current is diverted from Q320 base into capacitors C326 and C328. Q320 turns off, but because of the short RC time constant in its base circuit, the current is injected back into Q320 base after a few milliseconds Q320 turns on, and the cycle is repeated.

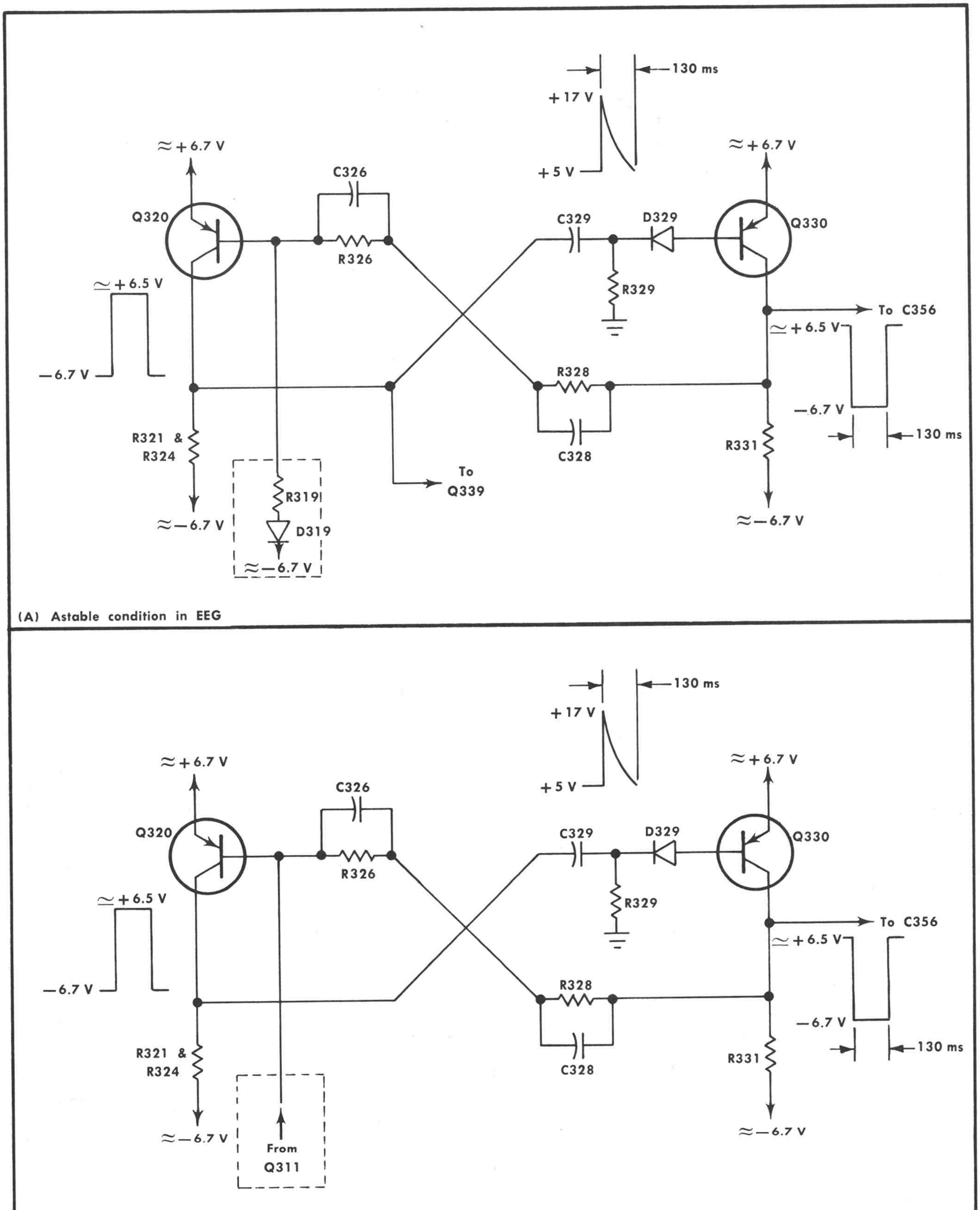
The second multivibrator mode to be discussed is the monostable mode that exists when the INPUT SELECTOR is set to ECG or AUX. The basic multivibrator operation is essentially the same as that previously described, except that the Q320 base current source is from the Trigger Discriminator circuit, as shown in Fig. 3-14B. Subsequent paragraphs will describe how and when the Trigger Discriminator supplies the switching current.

Trigger Discriminator

With the INPUT SELECTOR in the ECG and AUX positions, the Trigger Discriminator circuit controls the operation of the Trigger Multivibrator. Positive- and negative-going signal voltages are picked off the vertical deflection yoke terminals and enter the circuit through shaping networks R302-C302 and R306-C306. These integrator networks compensate for the increase voltage response due to increased frequency in the yoke coils.

The triggering signals are AC-coupled through C303 and C307 to D304 and D308, thus eliminating DC information such as vertical positioning. The signals are also made available to the OUTPUT connector through R301 and R307. D304 and D308 form a full-wave rectifier, allowing the triggering signal to be selected from either input. Both D304 and D308 conduct quiescently, drawing a few microamperes from the $-E_{BATTERY}$ supply through R309 and then passing the current through R304 and R308 to circuit ground. The triggering sensitivity is improved because of this pre-biasing; the signal does not have to overcome the approximate 0.7-volt diode turn-on barrier. D304 will conduct with each major downward deflection on the CRT screen, and D308 will conduct with each major upward deflection. Heart-related signals will typically contain one voltage excursion in one direction (such as the QRS complex) which is of greater amplitude than the others. This greater amplitude will dominate the operation of Q311 as discussed in the following paragraph.

Assume that initially Q311, Q335, and Q320 are not conducting and Q330 is on. A positive trigger arrives at the base of Q311 through the full-wave rectifier and causes Q311 to conduct. Refer to Fig. 3-15. The emitter of Q311 follows the



(A) Astable condition in EEG

(B) Circuit connection with INPUT SELECTOR in ECG or AUX. Monstable condition (astable after a signal loss).

Fig. 3-14. Partial diagram showing Trigger Multivibrator.

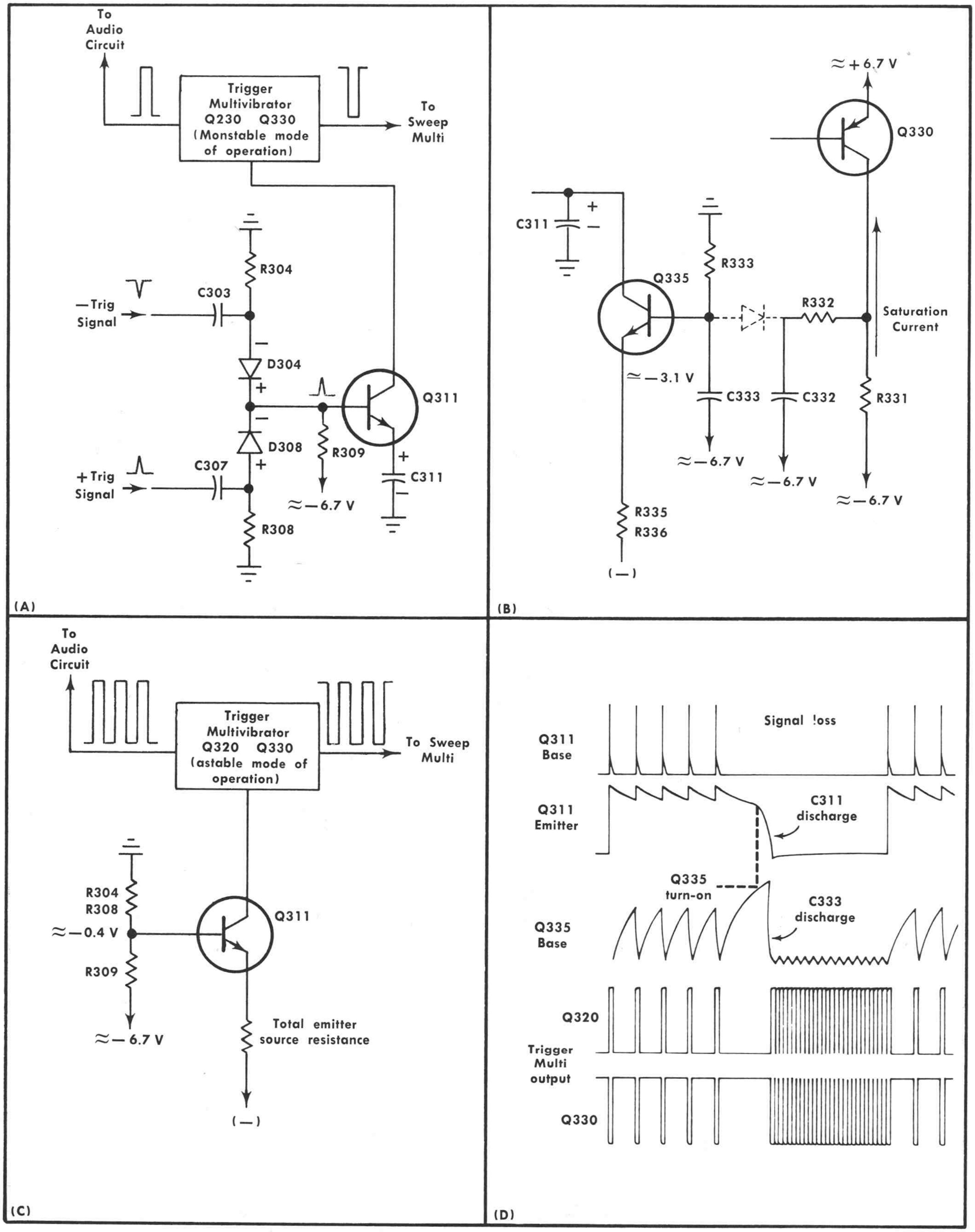


Fig. 3-15. Trigger Discriminator and Discriminator Reset operation; (A) Discriminator operation, (B) Discriminator Reset, (C) condition of Discriminator circuit after signal loss, (D) waveform relationship.

base, charging C311. The C311 charging current is injected into the base of Q320, turning Q320 on and Q330 off. When the trigger on the base of Q311 deteriorates, the charge on C311 holds Q311 emitter positive. Q311 turns off and C311 starts to discharge through the resistance network consisting of R311, R313, and R314. The Trigger Multivibrator, in the absence of a continuous base-current supply for Q320, recovers to its quiescent monostable condition of Q320 off and Q330 on in about 130 milliseconds. The Trigger Discriminator is now ready to again switch the Trigger Multivibrator as soon as the next trigger signal is received.

The third multivibrator mode is the astable mode that exists when the INPUT SELECTOR is set to ECG and AUX, and a loss of signal occurs. In this mode, Q311 becomes a continous Q320 base current source, and the multivibrator operates the same as described earlier. Converting Q311 to a continuous current supply is accomplished by the Discriminator Reset circuit, which is to be described next.

Discriminator Reset

The Discriminator Reset circuit is composed of Q335 and its associated circuit components. Refer to Fig. 3-15B for this discussion. Assume that the Trigger Multivibrator is operating in its monostable mode and is in its quiescent condition between trigger signals. Q320 is off and Q330 is conducting. C332 in the base circuit of Q335 is charging toward the saturation voltage of Q330 (about +6.5 volts), keeping D332 reverse biased. With D332 turned off, C333 charges toward ground potential through R333. Initially Q335 is reverse biaed and before C333 raises the base enough to turn Q335 on, assume that a positive trigger is received by the Trigger Discriminator and the conducting state of the Trigger Multivibrator is switched.

When Q330 turns off, its collector potential falls rapidly to about —6.7 volts. C332 then discharges rapidly, turning on D332 and discharging C333. After about 130 milliseconds, the Trigger Multivibrator recovers and swiches to its quiescent state. Once again the collector potential of Q330 steps positive, C332 starts to charge, D332 turns off, and C333 starts to charge toward ground.

Assume that a loss of signal now occurs. C333 continues to charge, and after about 2 seconds, the voltage across C333 rises to forward bias Q335. When Q335 conducts, the positive charge on C311 is removed and the emitter of Q311 is pulled slightly negative, allowing Q311 to conduct without a base signal input. See Fig. 3-15C.

With Q311 conducting continuously, the Trigger Multivibrator operates in its astable mode. On the first 130-milisecond negative pulse from Q330, C333 is discharged, turning Q335 off. D332 turns on with each negative pulse from Q330 and consequently C333 is kept near its discharged level. With Q335 turned off, C311 is permitted to charge if a trigger signal is recevied by Q311. Q311 will continue to conduct continuously until such a signal is received.

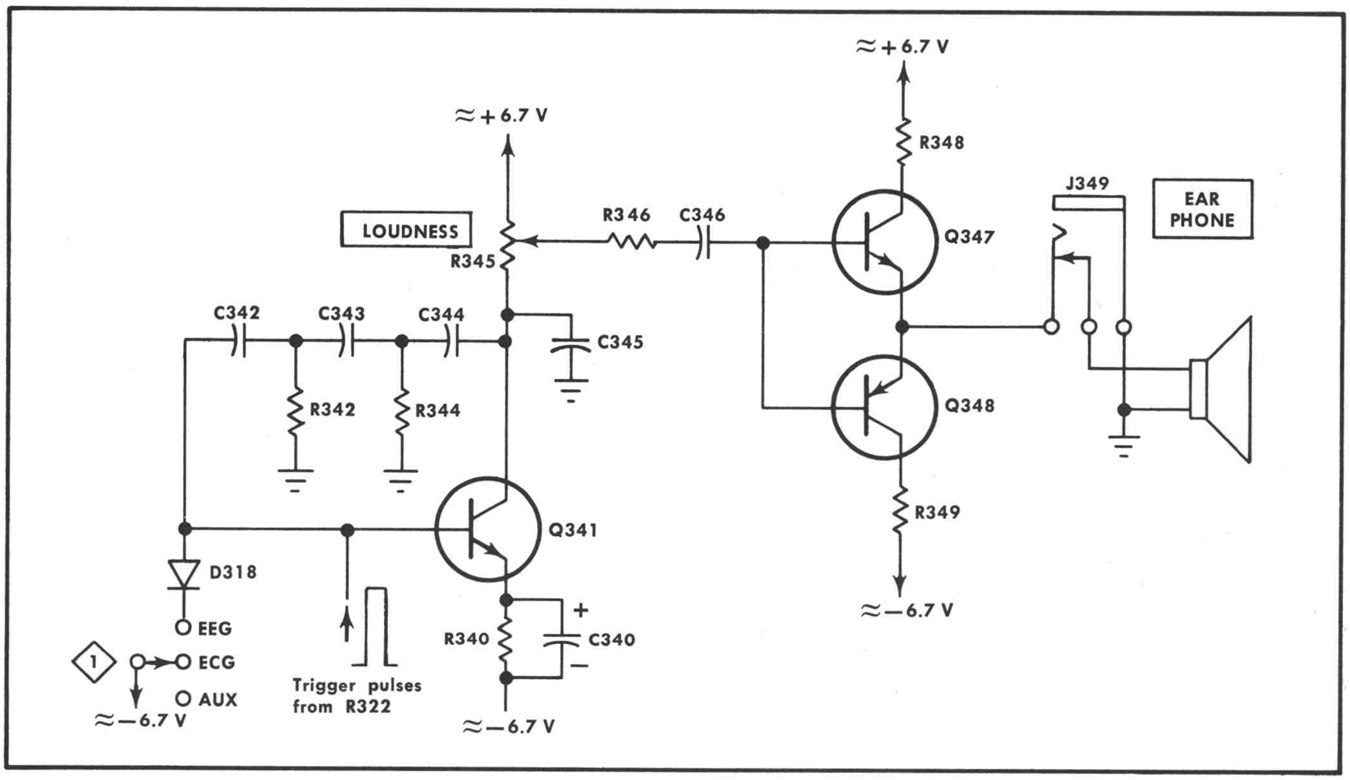


Fig. 3-16. Partial diagram showing the audio circuit with the INPUT SELECTOR in the ECG position.

Audio Circuit

The audio circuit is composed of an RC phase-shift oscillator[3] and a complementary symmetry common-collector amplifier[4] output stage (Fig. 3-16). Q341 is gated on by the 130-millisecond positive pulse through R322 from Q320, and it oscillates at about 2 kHz. Q341 turns off in the absence of the gating pulse because of the negaive potential applied to its base through R322 and R324. C324 helps to shape the 130-millisecond pulse for smoother oscillator turn-on, resulting in a more pleasant sound.

R345, LOUDNESS, control the signal amplitude to the audio output amplifier stage. The signal is coupled through R346 and C346 to the bases of Q347 and Q348. On the positive swing of the signal, Q347 conducts, and on the negative swing, Q348 conducts. With the emitters following the bases, the signal is reconstructed and drives the speaker with a maximum of about 40 mW of audio power. J349 provides for the use of a 100 Ω, or greater, earphone or an external speaker. With the earphone plug installed, the speaker is disconnected.

[3]Philip Cutler, "Semiconductor Circuit Analysis", McGraw-Hill, New York, 1964, pp. 544-552.
[4]Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics," second edition, McGraw-Hill, New York, 1962, pp. 11-57 through 11-62.

When the INPUT SELECTOR is in the EEG position, —E BATTERY is connected to the cathodes of D318 and D319, turning both diodes on. With the negative voltage applied through D318 to the base of Q341, the audio oscillator circuit is disabled.

Sweep Multivibrator

The Sweep Multivibrator is an electronic switch that turns the disconnect diodes, D368 and D369, off, allowing the sweep generator to produce a linearity increasing voltage ramp (sawtooth). See Fig. 3-17. Q351 and Q360 are connected as a bistable multivibrator; both transistors are on during the quiescent period between sweeps, and both are off during the time that the sweep ramp voltage is being generated.

Assuming the quiescent condition, both Q351 and Q360 are conducting. D368 and D369 are forward biased by the Q360 collector voltage and thus are conducting, and the timing capacitor C369 has essentially no charge. The output of the Miller Circuit is clamped to Q377 gate because both D368 and D369 have about the same voltage drop.

To start a sweep, the 130-millisecond negative pulse from the collector of Q330 is coupled through C356 and only the

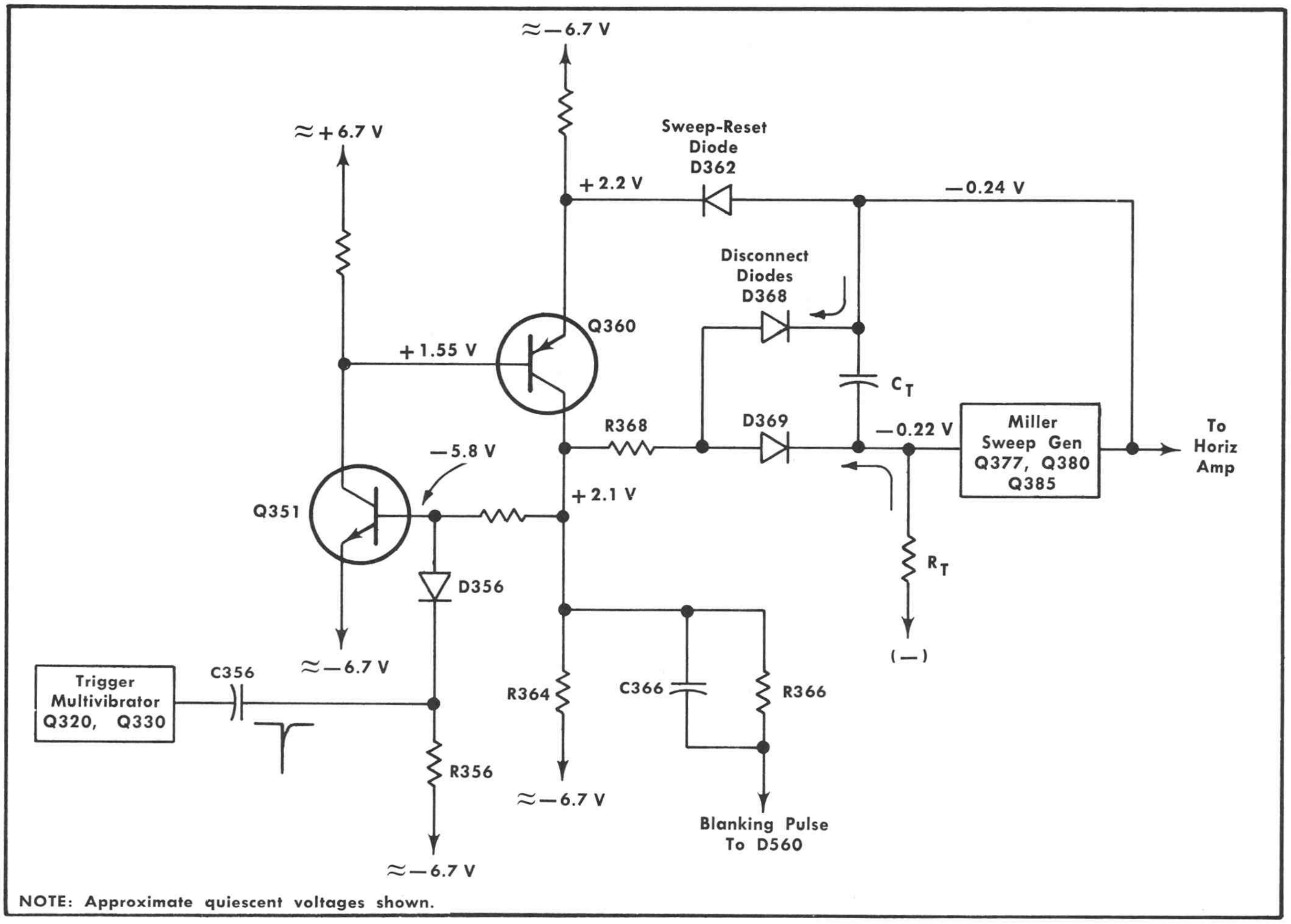


Fig. 3-17. Partial diagram showing Sweep Multivibrator in its quiescent state and its relationship to associated circuits.

leading edge of the pulse is conducted through D356 to the base of Q351. This action momentarily diverts current from the base of Q351, turning it off. K351 collector current ceases and Q360 turns off. The collector of Q360 goes negative and reverse biases D368 and D369, disconnecting the Miller Circuit from the Sweep Multivibrator and allowing a sweep sawtooth to begin. With Q360 off, Q351 has no base current source and will remain off.

When the sawtooth amplitude rises enough to forward bias D362, current is injected into Q360 emitter. Q360 turns on and injects turn-on current into Q351 base. Q351 saturates, injecting more current into Q360 base. This regenerative action of the circuit causes Q360 to saturate also, pulling its collector to about +2 volts. D368 and D369 become forward biased, restoring the Miller Circuit to its quiescent condition. In addition, the positive-going step at Q360 collector is coupled through C366 and R366 to the Blanking circuit to blank the CRT during retrace (see Blanking Circuit description).

When the sweep is terminated and Q360 turns on, R358 and C358 form a holdoff network by injecting more current into Q351 base than can be diverted by incoming trigger pulses, allowing the Miller Circuit time to recover to its quiescent condition. During the 20 to 40 milliseconds that it takes for C358 to charge when Q360 collector steps positive, any incoming negative triggers cause current to be diverted from the capacitor instead of from the base of Q351. C363 and C355 serve to bypass random noise spikes, etc, that otherwise may inadvertently cause switching of the Sweep Multivibrator.

Miller Circuit

The basic sweep generator circuit is an operational amplifier connected as an integrator (Miller Integrator circuit), and produces a linearly increasing voltage ramp (sawtooth) which when applied to the horizontal yoke coils drives the CRT beam across the screen at a constant speed. See Fig. 3-18. In the quiescent state—that is, when the sweep generator is triggerable but no sweep is being generated—the disconnect diodes are conducting, D368 drawing current from the emitter circuit of Q385 and D369 drawing current through the timing resistor (R370, R371, or R372) and R375, the Timing adjustment. Thus, Q337 gate and Q385 emitter voltages are approximately equal and the timing capacitor C369 has essentially no charge.

To start a sweep, the negative signal from Q360 collector reverse biases D368 and D369. The current through the timing resistor R_T does not cease, but instead begins to charge timing capacitor C369. The voltage level on the emitter of Q380 is set by the voltage divider on its base; thus, the current through R377 is held nearly constant. As the timing capacitor charges, the gate of Q377 goes slightly negative, decreasing the current through Q377. Since the current through R377 is held nearly constant, the additional current required by R377 is drawn through Q380 and R380. This results in a positive-going voltage change at Q380 collector, which is applied to the base of emitter-follower Q385. The positive-going sawtooth produced at Q385 emitter is fed back to the timing capacitor and opposes the Q377 gate voltage change. This action persists throughout the sawtooth period and limits the total Q377 gate voltage change to less than 0.1 volt. Since the voltage drop across the timing resistor is held nearly constant, the current through the resistor is essentialy a fixed value. This fixed current flows into the timing capacitor, producing a linearly increasing voltage (sawtooth) across the capacitor. The rate of the sawtooth rise is a function of the constant current through the timing resistor and the capacitance of C369.

The voltage output at the emitter of Q385 continues to go positive until D362 becomes forward biased and injects current into the emitter of Q360, resetting the Sweep Multivibrator. When Q360 turns on, its collector goes positive and forward biases disconnect diode D369. Since the timing capacitor still holds the charge developed during the sweep, D368 remains reverse-biased. The timing capacitor begins to discharge through D369. D368 will not conduct until the charge is nearly depleted. The removal of the timing capacitor charge forms the retrace or falling portion of the output sawtooth. The Miller circuit is then restored to the quiescent condition previously described.

The timing resistor is selected by SW380, SWEEP SPEED. The Timing adjustment, R375, allows calibration of this circuit for accurate mm/s sweep timing. D369 is a special diode that exhibits very low leakage under reverse-bias conditions. This characterisic prevents the diode from effectively altering the timing resistance value.

The positive-going sawtooth is connected through R390, Sweep Width, and R391 to the Horizontal Amplifier. R390 and R391 form a variable attenuator and control the amplitude of the sawtooth being applied to the Horizontal Amplifier.

Horizontal Amplifier

The Horizontal Amplifier circuit is shown in Fig. 3-19. Q401, Q431, and their associated circuit components form a paraphase amplifier that splits the sawtooth signal from the Miller circuit into a push-pull output signal. The positive-going sawtooth signal is applied to the base of Q401 and connected through R424 and R425 to drive the emitter of Q431. The output of the paraphase amplifier is a negative-going ramp voltage at Q401 collector and a positive-going ramp voltage at Q431 collector. These ramp voltage outputs are connected to the bases of amplifiers Q406 and Q436.

Amplifier Q406 and Q436 control the operating voltage levels applied to the horizontal deflection yoke. When the Miller circuit is in its quiescent condition and no sawtooth signal is being generated the quiescent condition of the Horizontal Amplifier is such that the voltage potentials applied to the yoke coils deflect the CRT beam to its starting position at the left-hand side of the viewing screen. Q406 is conducting a very small amount of current through R411, and Q436 is conducting heavily, drawing current through Q412, the yoke coils L555C and L555D, and D440. The CRT beam can be moved for purposes of calibration by adjusting R392, Horizontal Position. R392, R393, and R394 form a voltage divider, and adjustment of R392 results in a change of the DC level on the base of Q401.

As the ramp-voltage outputs of the paraphase amplifier are applied to the bases of Q406 and Q436, current increases through Q406 and decreases through Q436, producing a

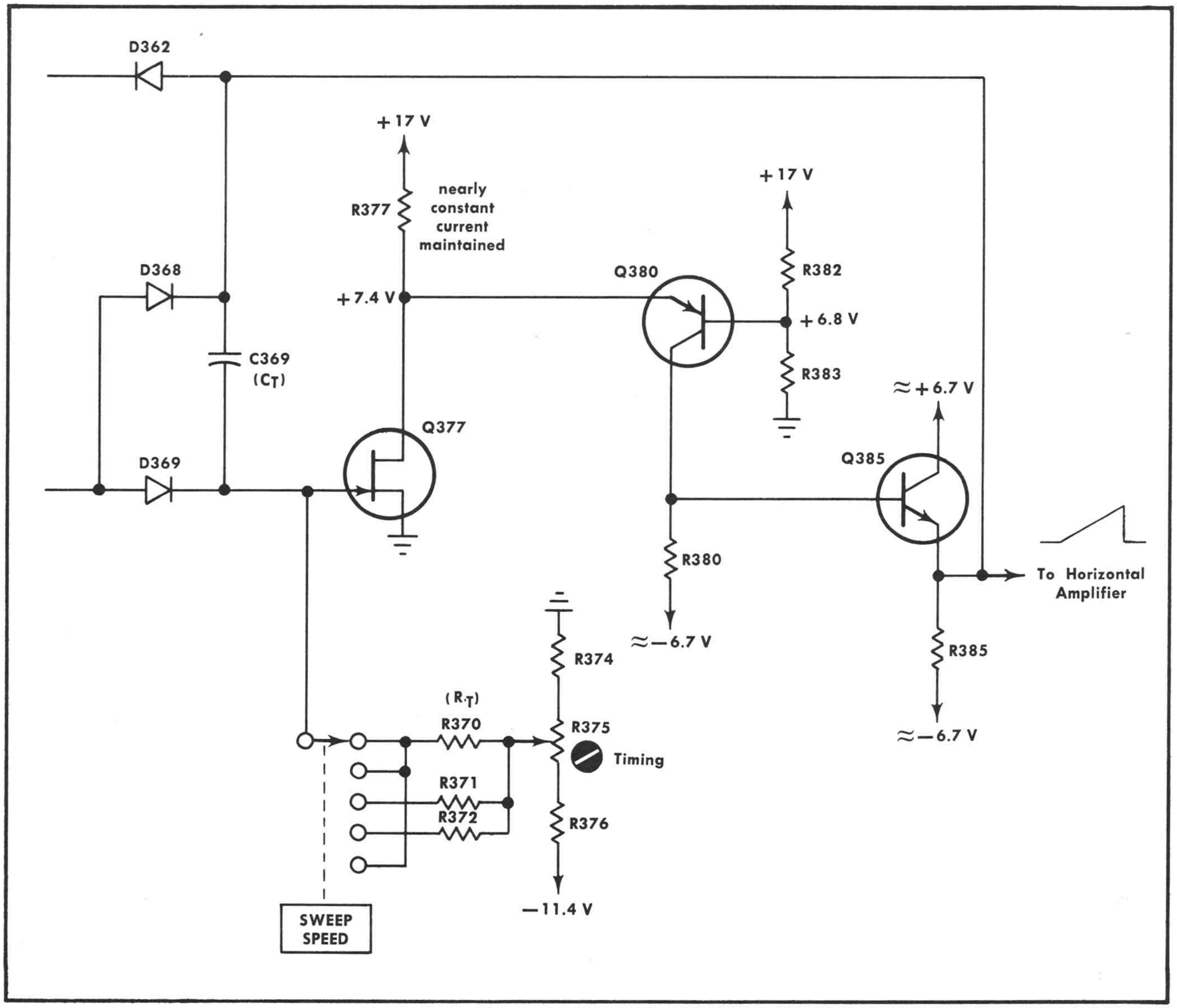


Fig. 3-18. Partial diagram showing Miller Integator sweep generator circuit.

positive-going voltage ramp at Q406 collector and a negative-going voltage ramp at Q436 collector. The voltage potentials applied to the yoke decrease, allowing the CRT beam to move toward the center of the screen. When the collector voltage of Q406 and Q436 pass through zero, Q412 and D440 become reverse biased and turn off, and Q42 and D410 turn on to furnish the current required by the increasing conduction of Q406. The voltage potentials applied to the yoke coils are now opposite in polarity to those applied during the first half of the sweep sawtooth, and the CRT beam continues to move to the right. When the sweep sawtooth is terminated, the Horizontal Amplifier is restored to quiescent condition.

R419 and R449 provide a negative feedback path to the emitters of Q401 and Q431. Current through Q401 and Q431 changes very slightly. The open-loop gain of the circuit is very high, but because of the feedback the actual gain is determined by the parallel combination of R424 and R423+R425, and the feedback resistors R419 and R449 (see Fig. 3-19). R425 compensates for the temperature coefficient of the copper in the yoke coils.

When SW380, SWEEP SPEED, is in the BATTERY CHECK position, the input of the Horizontal Amplifier is disconnected from the Miller circuit and connected to a voltage divider so that the Horizontal Amplifier and CRT become a slideback, expanded-scale voltmeter. The voltage divider, composed of R396, R397, R399, and D396, produces a DC level which is entirely dependent on the positive terminal voltage of the battery. This DC level is applied to the base of Q401 and produces an amount of horizontal deflection of the CRT beam which, when compared to the Battery Check Scale on the lower portion of the graticule, gives a visual indication of the battery state of charge (see First Time Operation). R397, Battery Check Cal, permits calibration of this circuit.

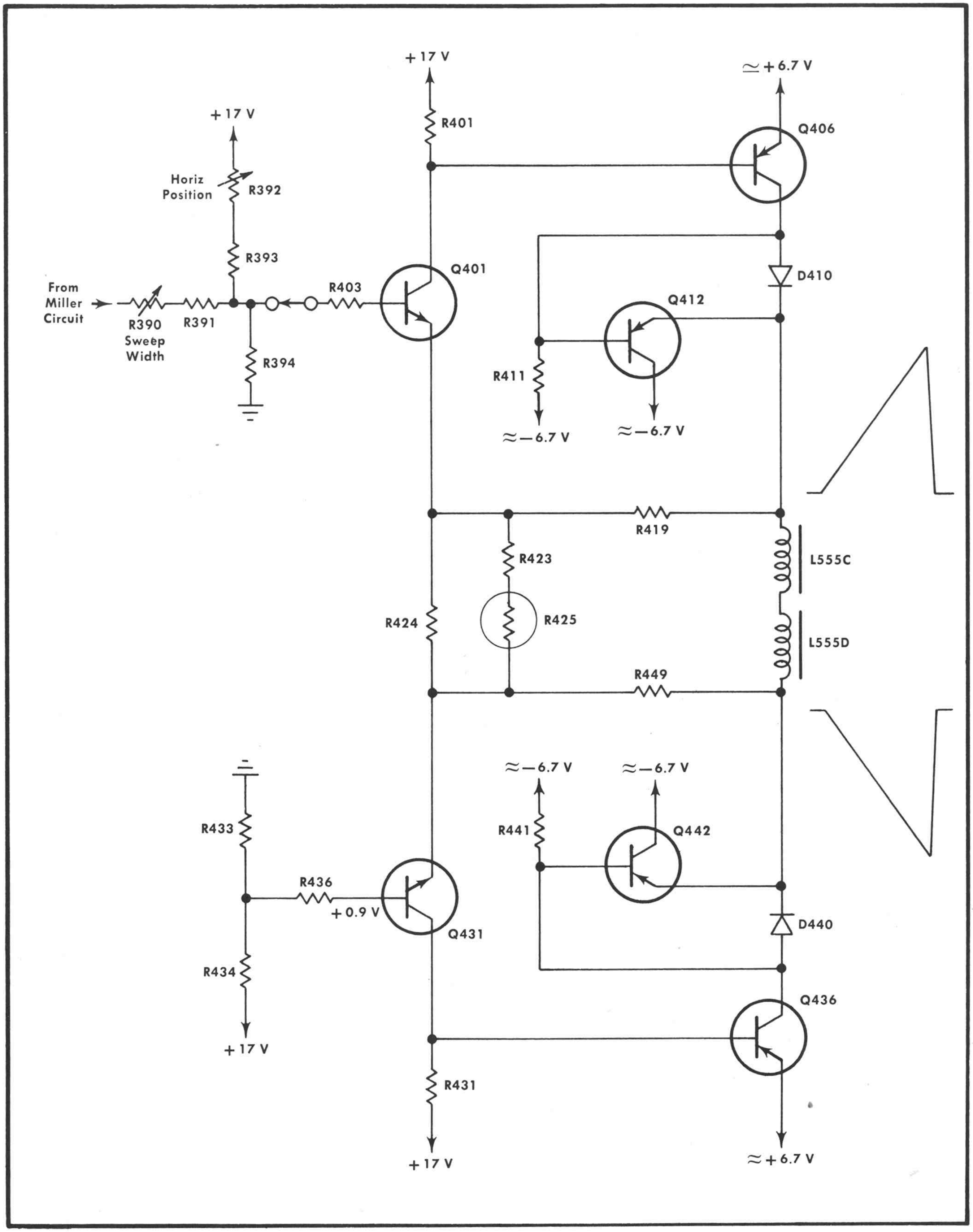


Fig. 3-19. Partial diagram showing horizontal amplifier.

CRT CIRCUIT

Power Supply

Q521, Q523, and the primary of T530 form a DC to DC power converter which operates as a nonsaturating-core sine-wave class C oscillator at about 40 to 60 kHz. Fig. 3-20 shows a simplified block diagram of the power supply and regulator circuit.

The +17-volt output is taken off the primary of T530, and the —5-volt and +175-volt outputs are taken off the secondary. The —11.4-volt supply is dervied by operating D590 at low current (hence producing —11.4 volts instead of —12 volts) through R590 from the —50-volt supply. D527, D528, D540 and D546, are half-wave rectifiers for the low-voltage supplies and their associated capacitors serve as filters D531, D532, D533, D534, D535, D536, and their associated capacitors form the High Voltage rectifier/multiplier and from the approximate 600 volts peak developed across the secondary of T530 produce the +3650 volts for the CRT anode. No bleeder action is provided to drain the charge on the High Voltage capacitors when the instrument is turned off; however, the High Voltage can be removed for maintenance purposes by discharging the capacitors to case or circuit ground through current limiting resistor R538.

At initial instrument turn-on the only voltages that exist in the oscillator circuit are the battery terminal voltages. The oscillator must start and build up to its final operating level to provide the low- and high-voltage supplies. This startup is accomplished as follows:

The base of Q507 is at circuit ground because C505 has no charge. + and $-E_{BATTERY}$ are applied to the circuit via the SWEEP SPEED switch at turn-on. Q507 conducts and its emitter potential is set to about —0.6 volts by the base-to-emitter drop. The base-emitter junction of Q510 is near a forward biased condition, but current through the transistor, if any, is very slight. With Q510 effectively off, a limited Q521-Q523 base current path is provided through the transformer windings, R512, and R510 to the $+E_{BATTERY}$ supply. Q521 and Q523 turn on to start oscillations. This startup network places the ocillator output at about 1/3 to 1/2 the final amplitude. R522 and C522 connected between the collectors of Q521 and Q523 help to suppress the tendency of the oscillator to pick up an incorrect mode of oscillation.

As soon as the —50-volt supply builds up enough to set the voltage across D590 at —11.4 volts, a reference is established for the regulator. With the +17-volt supply not yet built up, the negative voltage applied to Q507 base pulls the Q510 base negative. Q510 turns on, furnishing additional Q521-Q523 base current to build up the oscillator output.

The regulating circuit builds the oscillator output up to its final amplitude and keeps it at that level, thus regulating the output supply voltages. A voltage divider, composed of R501, R502 and R503, is placed between the +17-volt supply and the constant —14-volt reference. Any changes occurring in the +17-volt supply are applied through Q507 to the base of amplifier Q510. Here the change is inverted and amplified and is then applied to the bases of Q521 and Q523. Q507 is an emitter follower which isolates the high-

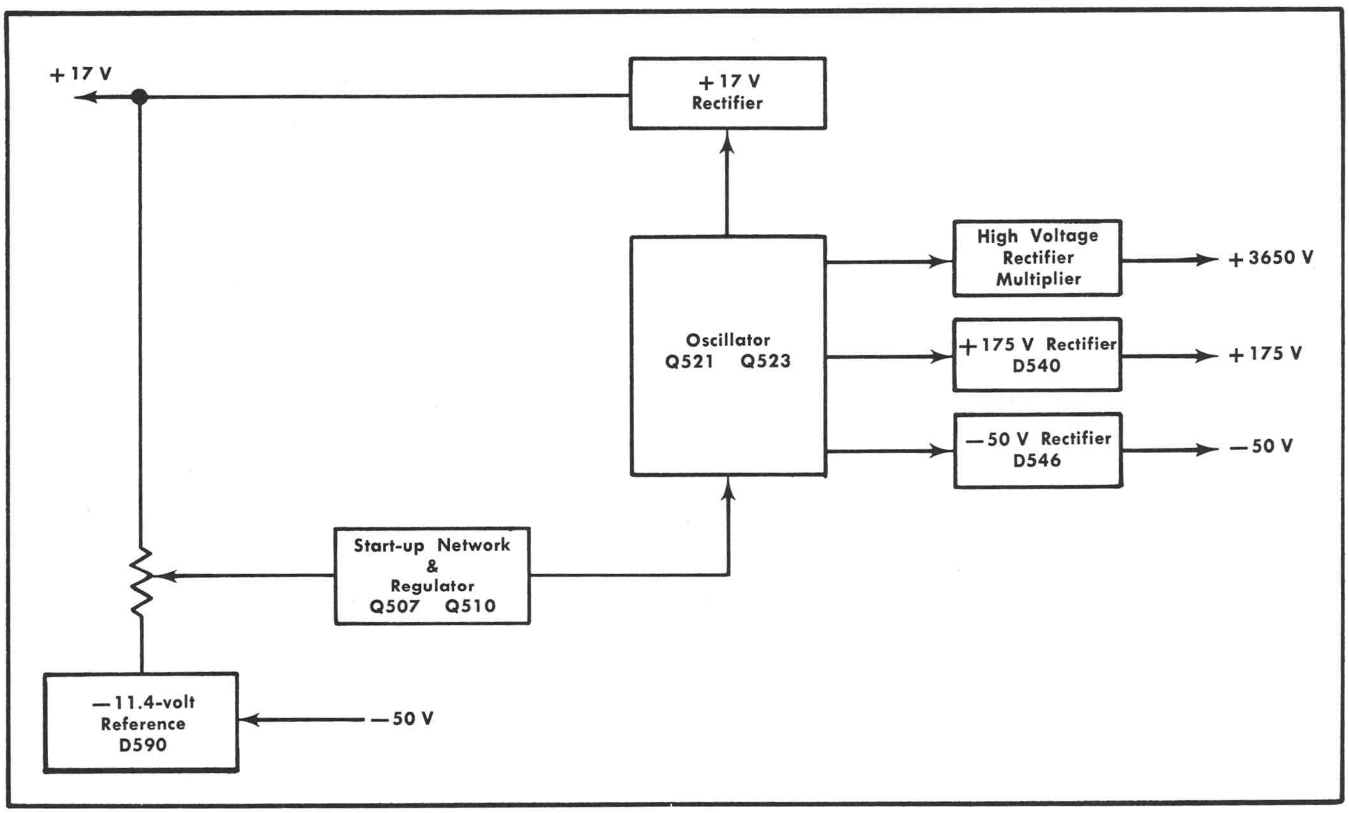


Fig. 3-20. Simplified block diagram of the power supply and regulator circuits.

resistance voltage divider from the low input resistance of the amplifier. R509 is of sufficient value to limit the current and prevent junction breakdown of Q510 in the event that the emitter of Q507 suddenly goes too far positive. Test points TP527 and TP595 are provided for measuring the +17-volt supply, and calibration is accomplished by adjusting R502 for +17 volts.

CRT

The CRT employs electrostatic focus and electromagnetic deflection. Because of constant beam current when turned on, the CRT has a fixed intensity. R550, Focus (internal adjustment), is provided for focusing the beam. The cathode is directly heated for good efficiency and fast warmup. The CRT cutoff voltage is ≈—35 volts.

Fig. 3-21 shows a simplified schematic diagram of the CRT circuit. Q560 and V555, the CRT, form a negative feedback circuit which sets the CRT grid voltage to any required level so that the CRT cathode voltage is held very close to ground. The fixed cathode voltage results in an approximate 6 μA constant beam current through the CRT.

A current-splitting technique is employed to set up the biasing conditions of the CRT. Because of Q560 V_{be} and the D562 junction voltage, the voltage at D562-D565 juncture is about —1.0 to —1.2 volts. A current of about 6 microamperes is established through R565, with the majority of this current flowing through D565 into the CRT and a few nanoamperes through D562 as base current for Q560. The negative feedback stabilizes to set up biasing conditions by which the 6 /A constant beam current through the CRT is maintained. The Q560 collector potential, and thus CRT bias, is typically —12 to —20 volts under the quiescent condition just described.

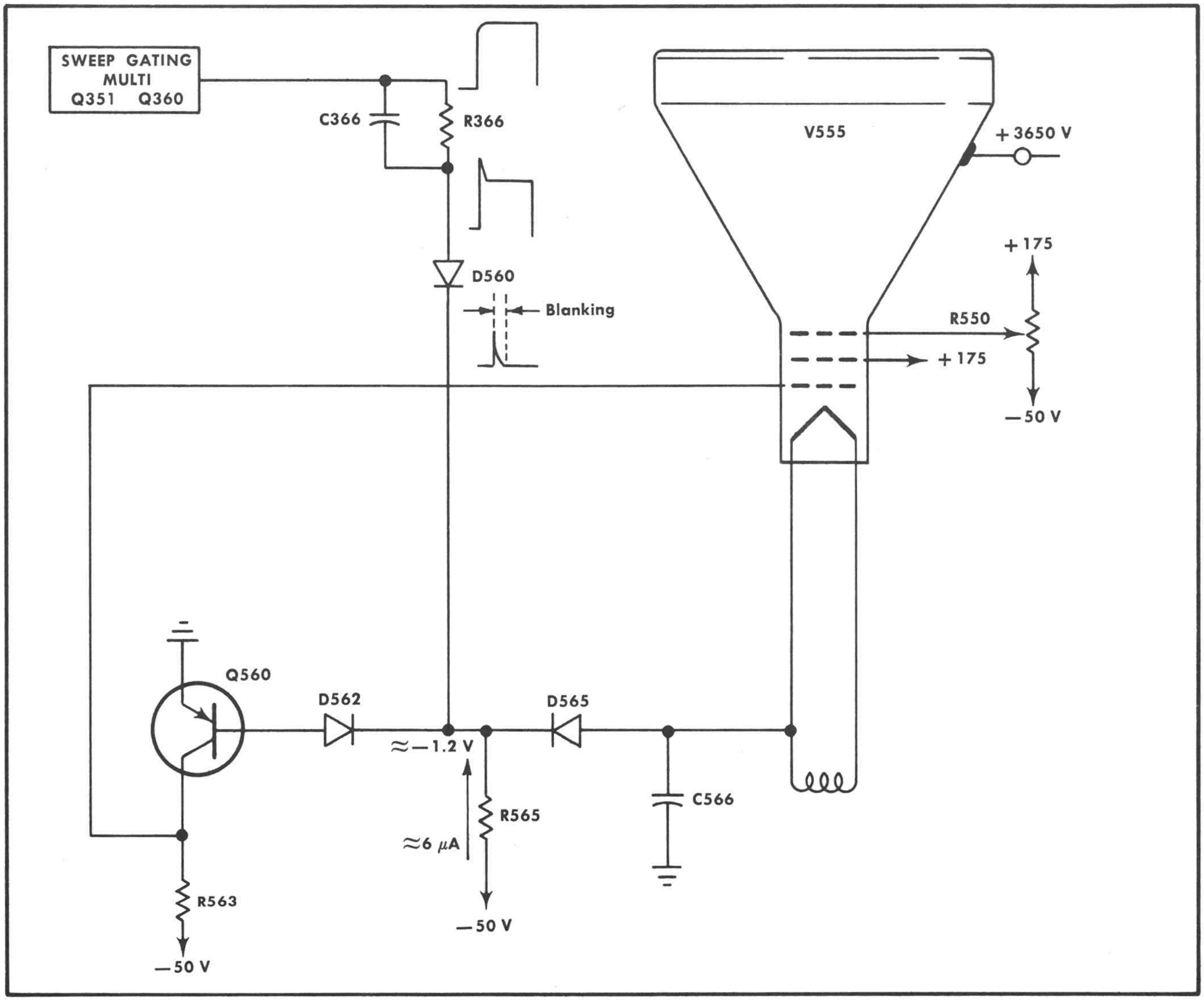


Fig. 3-21. Partial diagram showing CRT and blanking circuits.

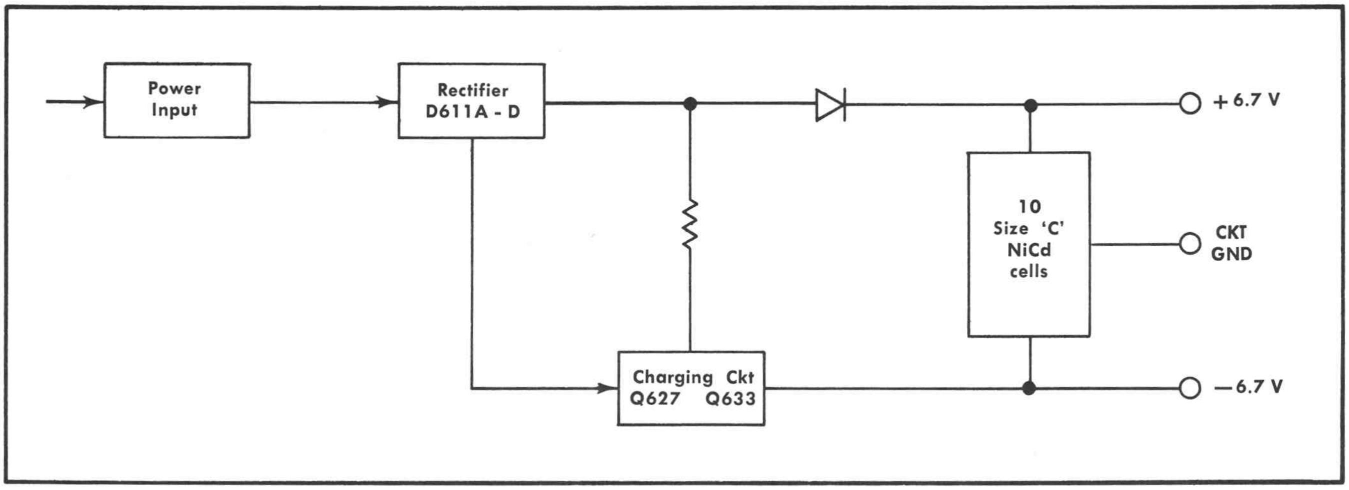


Fig. 3-22. Simplified block diagram of the power pack and charging circuit.

Blanking Circuit

It is desirable to turn the CRT off during sweep retrace, and this is accomplished by a short-duration blanking pulse. After 30 or 40 milliseconds, which is sufficient time for the sweep to retrace and the Miller circuit to stabilize, the CRT turns on again.

If a large transient charges C311 in the Trigger Discriminator circuit to an abnormally high value, it may take several hundred milliseconds for the capacitor to recover to a value that would permit lesser triggering signals to turn Q311 on and activate the sweep generator circuit. But because CRT turn-on is independent of the triggering and sweep circuits, vital vertical information is not lost.

When the sweep is terminated, the Sweep Multivibrator is reset and the positive-going step at the collector of Q360 is coupled through C366-R366 to the anode of D560. D560 turns on, allowing the blanking pulse to reverse-bias D562 and D565, and drawing the current from R565. Q650 turns off, its collector goes negative and cuts the CRT off.

The blanking pulse deteriorates after an RC-controlled time of 30 or 40 milliseconds, allowing D562 and Q560 to turn on and raise the CRT control grid out of cutoff. The CRT turns on and the negative feedback stabilizes, establishing the quiescent operating condition.

Power Pack

016-0107-00, Models 1 and 2

Fig. 3-22 shows a simplified block diagram of the power pack and charging circuit. The power pack contains ten size C rechargeable Nickel-Cadmium cells connected in series, providing approximate outputs of +6.7 volts, —6.7 volts, and circuit ground reference. See Fig. 2-29, for the average charge and discharge voltage curves of NiCd cells.

The battery may be recharged by connecting the power cord between the power pack and the line voltage of either 115 VAC or 230 VAC. The 115 VAC-230 VAC selector switch, SW603, connects the two primaries of T601 in parallel for 115 VAC operation, or in series for 230 VAC operation. SW603 can be located by removing the power pack from the instrument (see Section 2, First Time Operation). Fuses F601 and F602 are connected in series with the primary windings for 115 VAC operation. For 230 VAC operation, only F601 is connected in series with the primary. Resistors R604 and R605 are connected in series with the T601 primary windings to limit the initial filter capacitor charging surge when the power pack is connected to the line voltage.

Charging current of about 180 milliamperes for the battery is established by the voltage developed across R635 (Q627 V_{be}) and is supplied through Q633. Q627 limits and regulates the charging current by diverting base current from Q633. D621 prevents battery discharge via R625 when the power pack is disconnected from the line voltage.

016-0107-02, Models 1, 2, and 3

When battery voltage is normal (charged battery), Q680 is cut off. If the battery voltage decreases to approximately 11 volts, the potential at the junction of R664, R666 drops to about 5.6 volts and Q680 comes into conduction. As the battery voltage decreases further the current in R660, R662 and R664 decreases. Since the current in R666 is now fixed by the voltage acorss R666, the current in Q680 increases.

The increased current in R682 provides turn-on potential for the Darlington amplifier, Q682, Q683, providing current to the latching relay, causing the relay to switch to its AC position.

Switching the relay to its AC position changes Q680 collector load from 470 k to 2.7 k ohms, removing the operating potential from the Darlington amplifier, removing the relay operating current.

The Type 410 will not now operate until the Power Pack line cord is connected to line voltage. When connected to line voltage the Power Pack provides a regulated output current to power the instrument and charge the battery.

In the first few minutes of operation after connecting to line voltage (on low battery) the battery is charged at a rate of 5 to 15 mA. This charging current is set by Q688, a FET connected as a current limiting diode.

As the battery voltage rises the voltage across the divider, R660, R662, R664, R666 increases, applying an increasing voltage to the base of Q662. Q662 conducts, providing operating voltage for the modified Darlington amplifier, Q650, Q654, providing current to operate the latching relay to the BATT position.

Operation of the relay to the BATT position reduces the voltage from Q650 emitter to Q654 collector to approximately 0.7 volts, removing current from the latching relay.

Operating of the relay to the BATT position also bypasses Q688, allowing full charging current, provided by Q633 to charge the battery.

Battery charging current with the Type 410 turned off is a constant 240 mA. Since the Type 410 draws approximately 150 mA of operating current at maximum load, the battery charging current at maximum load is approxiamtely 90 mA.

The regulator circuit consists of Q625, Q627 and Q633. Q625, Q633 act as a voltage regulator. If the load current demand exceeds 240 mA, Q627 is biased on by the voltage drop across the divider R628, R631. Q627 collector current diverts some current away from Q633 base, thereby reducing Q633 collector current, limiting the total current to instrument and battery to 240 mA.

Zener diodes VR641 and VR643 provide a low impedance path to ground for cauterization and defibrillation signals which might harm the Power Pack circuitry if operating with the battery disconnected.

Diode CR688 prevents any current flow to the instrument when the relay is in the AC position and the Power Pack is not connected to the power line.

016-0107-02 Models 4 and Up

Relay K670 and its associated circuitry furnish automatic switching from battery operation to AC line operation, if the battery terminal voltage falls below approximately 11 volts. The circuitry also switches back to battery operation after the battery charge has been restored.

The Power Pack provides charging current, (when connected to the AC power line) at approximately 240 mA when the instrument is turned off, or at approximately 90 mA while the instrument is operating on batteries.

If the battery voltage is low and the Power Pack is connected to the AC line, the initial charge current is limited to approximately 10 mA. After a few minutes of operation on the AC line the relay switches to BATT operation. When the switch to battery occurs, the 10 mA current limit is bypassed and the charging current increases to approximately 240 mA (instrument turned off) or approximately 90 mA (instrument turned on).

The switching circuitry consists of a pulsing circuit, a gated current sink, a voltage comparator, a reference voltage, a relay drive circuit, and a latching relay.

The pulsing circuit (Q654, C651, R651 and R654) provides a millisecond pulse to Q659 base every 10 seconds. C651 charges through R651 for approximately 15 milliseconds. The voltage drop across R654 during C651 discharge drives Q659 into saturation.

Q659 (during saturation) passes operating current for the compartor, Q666-Q684. Either Q666 or Q684 will conduct depending on the potential at Q666 base, relative to the reference level on Q684 base, set by VR680. If the battery is charged, Q666 base is more positive than Q684 base: therefore, Q666 turns on and Q684 turns off (when current is gated in by Q659).

Q666 conduction turns Q670 on, furnishing current to the BATT winding of the relay K670.

If the battery voltage drops to approximately 11 volts, the potential at Q666 base is more negative than Q684 base; therefore, Q684 turns on and Q666 turns off (when current is gate in by Q659).

Q684 conduction turns Q686 on, furnishing current to the AC winding of relay K670, which switches the relay to the AC position.

If the relay switches to AC position, with low battery condition, the instrument will cease operating until the Power Pack is connected to the AC power line.

When the Power Pack is connected to the power line (and battery potential is low) the relay will remain in the AC position. The charging-regulation circuit limits the battery charging current to approximately 10 mA (Q688 connected as a diode) with the remaining 240 mA available for the instrument, should it be required. Due to the rapid rise in terminal voltage (battery discharged) during the first few minutes of charge, the voltage at Q666 base rises to a level more positive than Q684 base and the relay switches to BATT operation.

When the relay switches to BATT the current limit, (Q688), is bypassed, allowing the battery charging current to increase to approximately 240 mA with the instrument off. Since the Type 410 draws approximately 150 mA at maximum load, the battery charge current during "Instrument on time" is approximately 90 mA.

If the load current demand exceeds 240 mA, Q627 is biased on by the voltage drop across the divider R628 and R631. Q627 collector current diverts some current from Q633 base, reducing Q633 collector current, limiting the total current to the instrument and battery to 240 mA.

CR670 and CR671 provide protection for Q670 and Q680 by limiting induced voltage surges across the relay coils.

CR650 and CR684 provide a means of connecting the higher of the two voltage sources, battery or rectifier to the relay drive circuitry.

D640 disconnects the rectifier circuitry from the battery during battery operation (instrument not connected to AC supply).

CR688 prevents any current to the instrument when the relay is in the AC position and the Power Pack is not connected to the power line.

VR641 and VR643 provide a low impedance to ground for cauterizing and defibrillating signals that might harm the Power Pack circuitry when operating with the battery disconnected (AC operation).

NOTES

SECTION 4
MAINTENANCE

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

This section of the manual contains information for use in preventive maintenance, corrective maintenance, and troubleshooting of the Type 410.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication of switches, etc. Preventive maintenance performed on a regular basis will help minimize instrument failure and will improve reliability of the instrument. The severity of the environment to which the Type 410 is subjected will be a consideration in determining the frequency of maintenance.

Interior Cleaning

The case provides protection against dust in the interior of the instrument. However, the instrument should be thoroughly cleaned internally every few years. Accumulation of dust on the components acts as an insulating blanket and prevents efficient heat dissipation.

TABLE 4-1

Instrument Part	Material
Cabinet (painted surfaces)	Vinyle base paint
Side Castings	Chromium plating
Battery case, Handle Grip and spacers, Potentiometer washers	Delrin® Plastic
Knobs	ABS Plastic
Handle end cap	Nickel plating
Lettering	Enamel ink
Gaskets	Neoprene
Support chassis (rear bulkhead)	Clear lacquer
Speaker cone and spacers	Paper or fiber
Tags	Anodized aluminum
Screws	Cadmium plating

The recommended method of cleaning the exterior surfaces of the instrument is with warm water and mild soap.

The battery pack should be removed during major cleaning of the instrument.

Avoid getting liquid into the speaker grille as it may damage the speaker cone.

Exterior Cleaning

Avoid the use of cleaning agents that might damage the materials used in the Type 410. Table 4-1 lists the external surfaces and the materials of which they are made.

Recalibration

To assure accurate measurement, check the calibration of this instrument after each 1000 hours of operation or every year, if used infrequently. Complete instructions are given in the Calibration section.

The Calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases minor troubles, not apparent during normal use, may be revealed and/or corrected by recalibration.

Lubrication

The reliability of rotary switches and other moving parts, except potentiometers, can be increased if they are kept properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part Number 006-0218-00) on shaft bushings and switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part Number 006-0219-00). Do not over-lubricate. Lubrication at 5 year intervals should be adequate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order Tektronix Part Number 003-09342-00.

Visual Inspection

The Type 410 should be inspected occasionally for such defects as broken connections, improperly seated transistors or FET's (Field-effect transistors), damaged etched wiring boards and/or heat-damaged parts.

The remedy for most visible defects is obvious. However, care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of overheating before the heat-damaged part is replaced. Otherwise, the damage may be repeated.

Transistor and FET Checks

Periodic checks of the transistors and FET's in the Type 410 are not recommended. The best check of transistor or FET performance is its actual operation in the instrument. More details on checking transistor and FET operation is given under Troubleshooting.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques or procedures required to replace components in this instrument are described here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 410 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts locally, consult the Parts List for value, tolerance, and rating.

NOTE

All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the Type 410. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the Parts List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument Type

2. A description of the part (if electrical, include circuit number).

3. Tektronix Part Number

4. Instrument Serial Number.

Soldering Techniques

NOTE

Always disconnect the power cord before soldering. When soldering in the instrument always remove the battery pack. When soldering in the battery pack remember that the cells can deliver very high current.

Circuit Boards. Use ordinary 60/40 solder and a 15 to 40 watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

The following technique should be used to replace a component on a circuit board.

Remove the circuit board from the instrument for best results.

Wire colors and pin letter designations are shown in Figs. 4-16 through 4-19.

1. Grasp the component lead with long nose pliers. Touch the soldering iron to the solder fillet on the under side (side opposite the component). When the solder melts gently pull the lead out of the hole. If the hole in the board is not open after the component lead has been pulled free, reheat the solder and clean the hole with a vacuum desoldering tool, a toothpick or other pointed object.

2. Bend the leads of the new component to fit the holes in the board. Place the new component leads through the board, seating the component against the board surface. Hold the component lead with long nose pliers to prevent damage to the component. Solder the lead into place from the under side of the board and trim off any excess wire end.

3. Clean the area around the soldered connection with a flux solvent. Be careful not to remove information printed on the board.

Metal Terminals. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. The soldering iron should have a 15 to 40 watt rating with a 1/8-inch wide chisel-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder joint, clip off the excess.

4. Clean the flux from the solder joint with a flux solvent.

Component Replacement

Removing the Rear Cover. Place the Type 410 flat (not tilted up on the handle) on a table. Place the thumb near the front edge of the top of the back cover. Press downward with the thumb to release the front edge from the lip on the main housing. Tilt the top of the cover toward the rear of the instrument and slide the cover free. To replace the cover, reverse the above procedure.

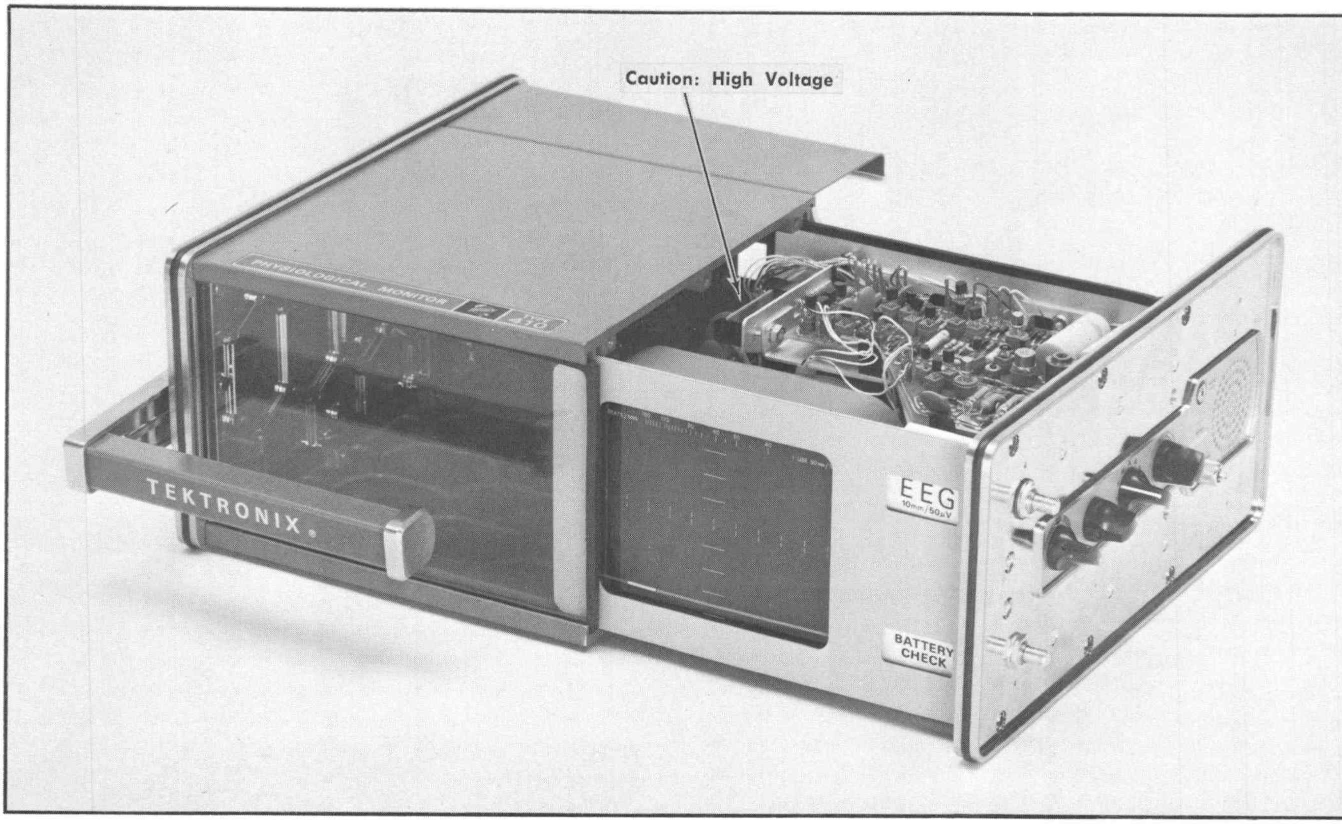


Fig. 4-1. Location of the high-voltage capacitors.

Fig. 4-2. Removing the Type 410 from the case.

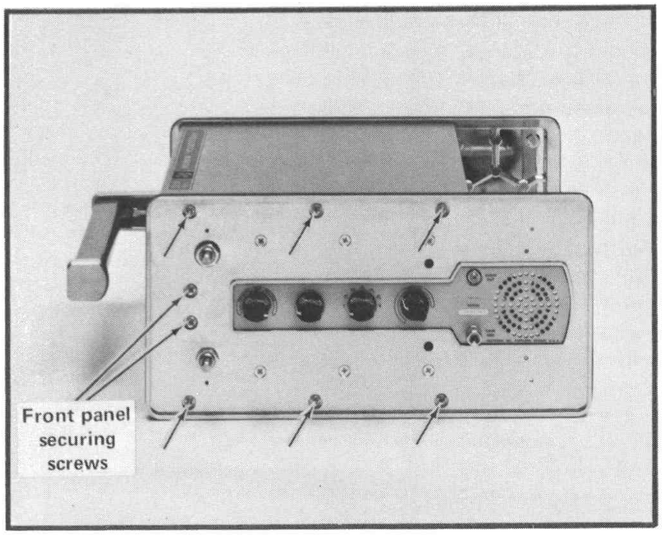


Fig. 4-3. Location of the screws which secure the side panel to the main casting.

Disassembling the Type 410. Remove the rear cover and the battery pack. Loosen the recessed hex. screw in each of the large knobs (INPUT SELECTOR and SWEEP SPEED) on the side panel, using a $^{1}/_{16}$-inch hex. wrench. Remove the knobs, exposing two Phillips head screws. Remove these two screws and the other two screws securing the overlay. Remove the overlay.

Remove the six Phillips head screws recessed into the side panel, Fig. 4-3.

CAUTION

High voltage is present inside the Type 410. The high voltage circuit provides no bleeder action to drain off the capacitor charge. See Fig. 4-1. Avoid touching these components when sliding the case apart.

Grasp the instrument as shown in Fig. 4-2 and gently but firmly slide the instrument and its right side panel away from the rest of the case.

Removing the Cathode-Ray Tube. Remove the four yoke leads from the square pin connectors Q, R, S, and T on the Vertical circuit board. See Fig. 4-4.

Remove the two yoke leads from the square pin connectors S and T on the Horizontal and Audio circuit board. See Fig. 4-5.

CAUTION

Discharge the high voltage capacitors. As there is no bleeder resistor in the high voltage circuit, the capacitors will retain a charge. Discharge the capacitors from the CRT anode lead side of the 2.2-megohm resistor, R538, to the chassis. See Fig. 4-6. Discharge of these capacitors from the capacitor side of R538 may damage many diodes and transistors throughout the instrument. Remove the high voltage connector from the CRT anode button. See Fig. 4-7.

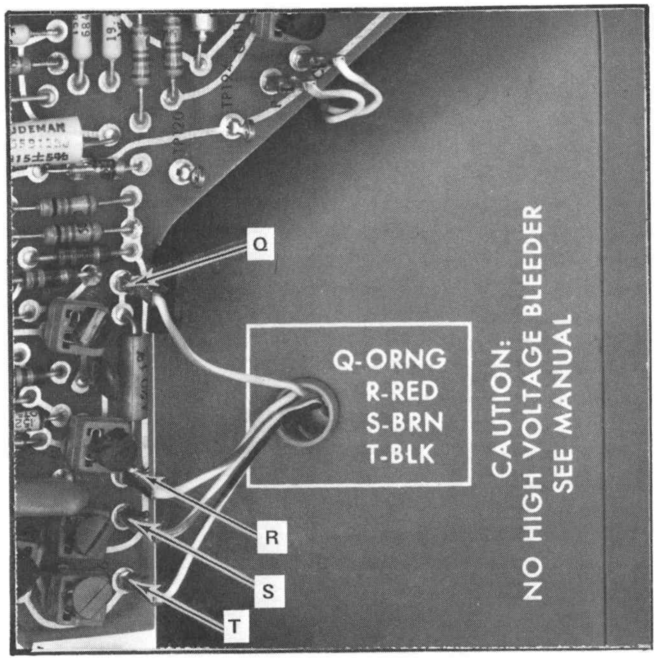


Fig. 4-4. Location of the square-pin connectors Q, R, S and T.

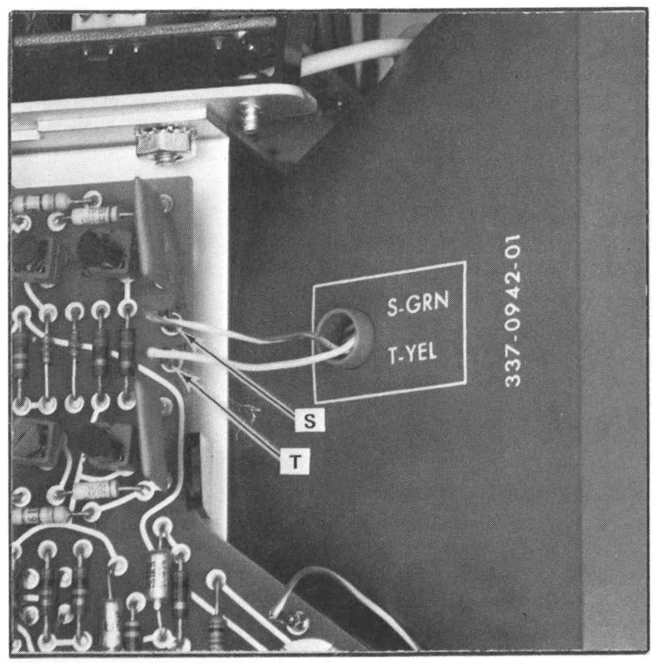


Fig. 4-5. Location of the square-pin connectors S and T.

Remove the two screws, Fig. 4-3 holding the panel in place. Slide the panel and CRT assembly out far enough to remove the 7-pin CRT base socket from the CRT base.

CAUTION

Use care in handling the CRT. Due to the high vacuum that exists inside the CRT, scratching any of the external surfaces or rough handling increases the implosion hazard.

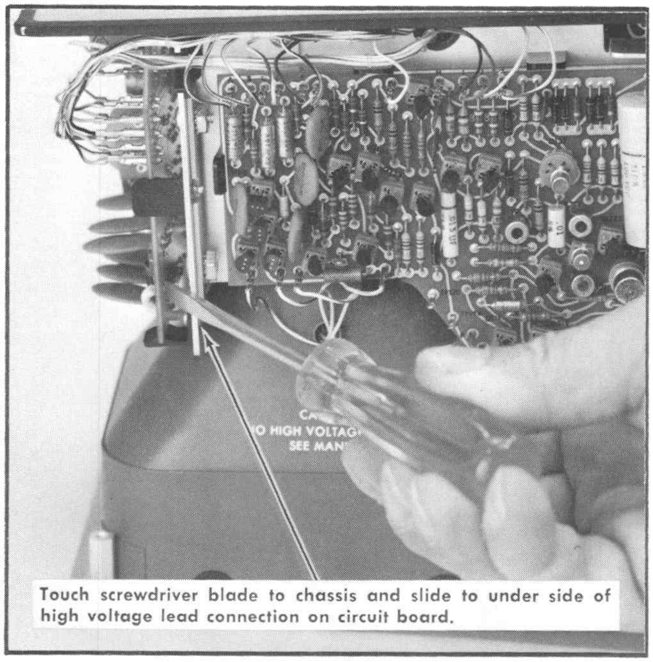


Fig. 4-6. Discharging the high voltage capacitors.

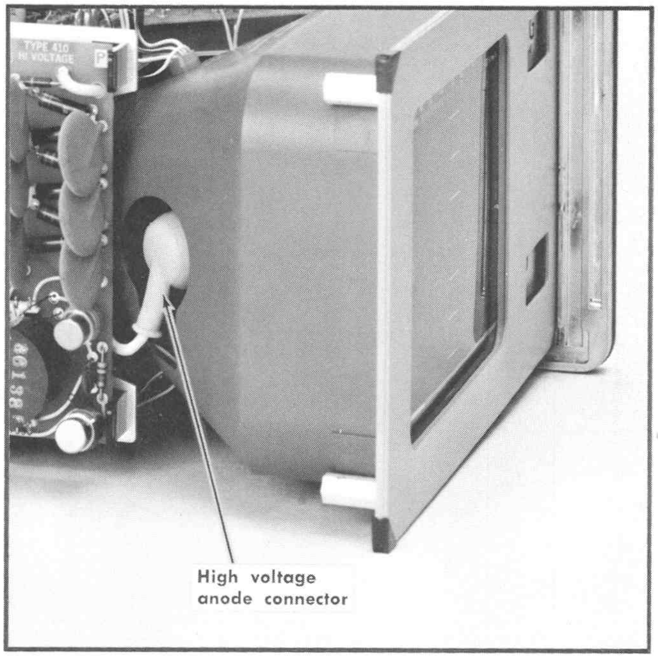


Fig. 4-7. Location of the high voltage CRT anode connector.

Removing the CRT from the Shield. Place the assembly, CRT face down, on a flat surface and proceed as follows:

1. Remove the 4 hexagonal securing studs at the corners of the CRT shield.

2. Lift the CRT shield away from the CRT.

3. Pull the 6 wire leads through the holes in the shield and remove the shield.

4. Slide the yoke off the CRT neck.

Replacing the CRT in the Shield. Using Fig. 4-8 as a reference, reassemble the CRT, yoke, shield, etc., as follows:

1. With the shield lying on one edge (CRT anode opening up) place the CRT shockmount ring inside the shield opening.

2. Place the yoke on the CRT neck.

3. Place the CRT neck into the shield far enough to start the yoke leads through the lead holes in the shield, yellow-on-white and green-on-white through the hole marked S-GRN and T-YEL, and the remaining four leads through the hole marked Q-ORNG, R-RED, S-BRN, and T-BLK.

4. Push the CRT into the shield until the CRT face is even with the end of the shield.

5. Pull the excess yoke leads through the holes.

6. Grasp the CRT shield with the fingers of both hands (Fig. 4-9) and push on the CRT face with the thumbs until the CRT face is approximately 1/2 inch below the front edge of the CRT shield. The CRT should stay down when released.

7. Clean the CRT face with a clean, soft cloth.

8. Hold the assembly with the CRT base down and the shield anode cutout to the left.

9. Place the CRT retainer ring into the end of the shield.

10. Use a soft cloth to clean the back side of the plastic graticule and place it, printed side up, into the CRT retainer ring with the red end of the scale toward the anode button side.

11. Place the panel over the shield with the switch position indicator openings to the right.

12. Pass the 4 panel screws through the shield corner holes.

13. Place the hexagonal studs on the four corner screws.

14. Push on the base of the CRT until the CRT slides into place against the plastic spacer ring.

NOTE

Do not fasten the panel to the side of the instrument case until the yoke position and centering adjustments have been made. The procedure for position and centering is given in the Calibration Procedure. Section 6, in this manual.

Handle Disassembly. Should replacement of the carrying handle be necessary a special kit (Tektronix Part Number 050-0386-00) is available with instruction for use. The kit includes a new overlay with adhesive.

CRT Circuit Board Removal

Release the circuit board from its chassis mounting clips by springing the clips away from the board edge.

If it is desired to remove the board completely, remove the lead connectors from the square pin connectors. The

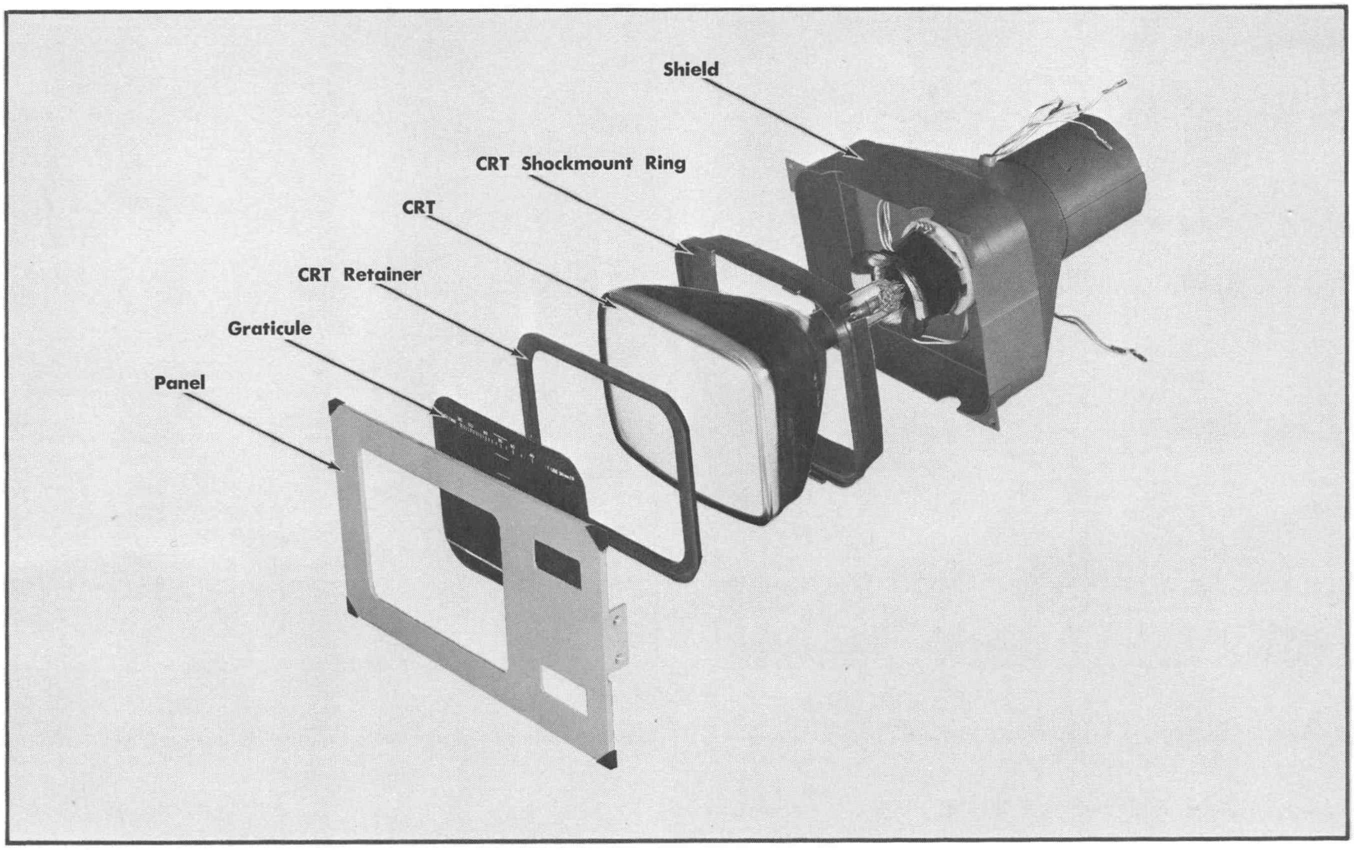
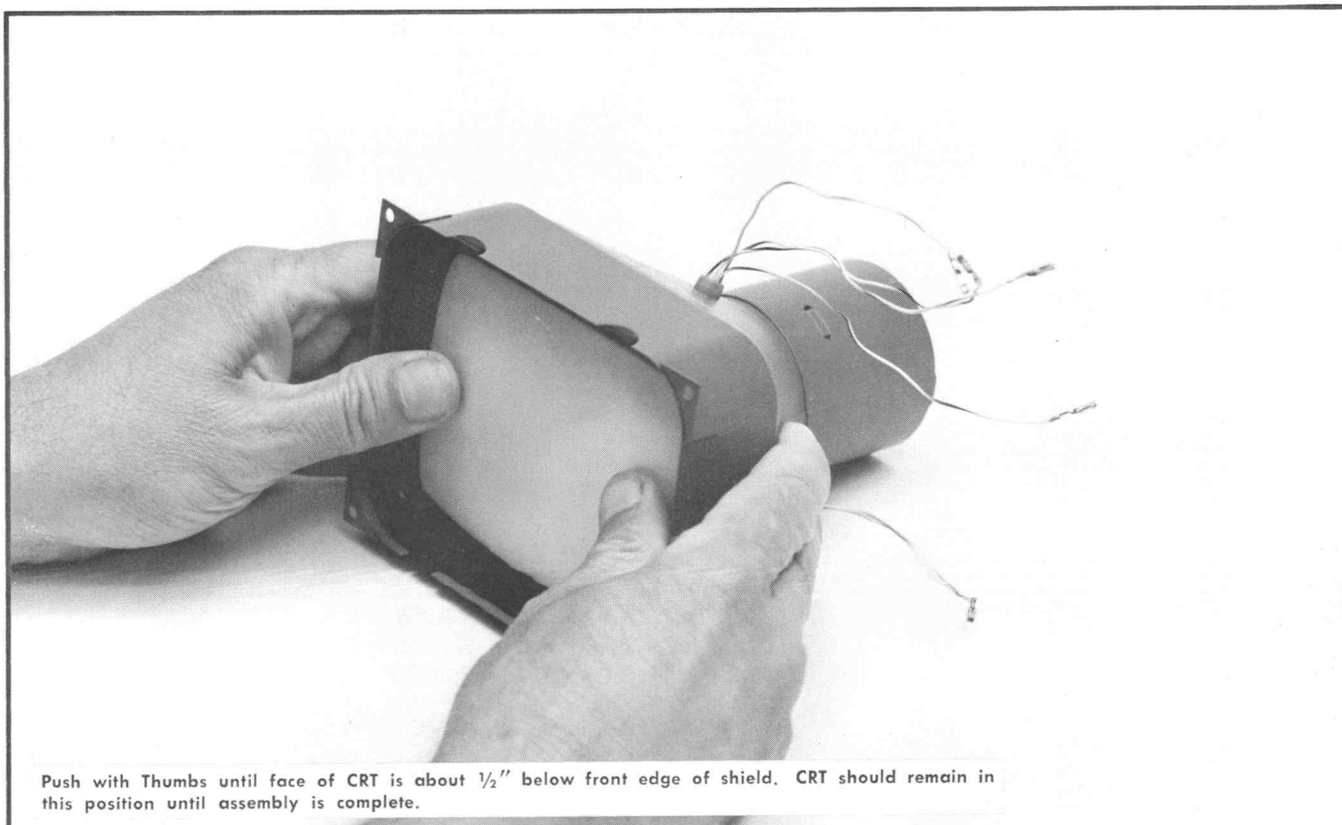


Fig. 4-8. Replacing the CRT in the shield.



Push with Thumbs until face of CRT is about ½″ below front edge of shield. CRT should remain in this position until assembly is complete.

Fig. 4-9. Pushing the CRT into the shield.

lead color codes for the interconnecting wires is given in Fig. 4-15 through 4-20.

Removal of Other Circuit Boards. The two other circuit boards in the instrument may be removed in the same manner as above, except for 3 soldered input connections on the Vertical board, by lifting the board while pushing the securing clips away from the board edge.

NOTE

Observe the soldering precautions given under Soldering Techniques in this section. If the underside of the board must be reached or if the board must be moved to gain access to other areas of the instrument, the board may be lifted out without disconnecting the leads from their connectors.

Circuit Board Replacement. Position the circuit board with one edge into one or two of the securing clip notches. Press the board gently toward the chassis so that the remaining clips spring open to accept the board. If the board is positioned correctly, very little pressure is required to snap the board into the clips.

Reassembly of the Type 410. Check that the corners of the square pins and connectors are properly aligned before the connectors are pushed all of the way down on the square pins. Bend the square pin connector leads toward the board to prevent rubbing on the case when reassembling.

Be very careful with the gasket when sliding the sections of the case together.

NOTE

The 12-pin connector (Patient Cable), the VERTICAL SIZE and the ECG LEAD SELECTOR controls and the AUDIO OUT jack are insulated from the case. If replaced, check for isolation from the case after installing the new part.

Disassembly of the Battery Pack. Remove the Battery Pack from the instrument as described in Section 2 of the manual.

CAUTION

1. Do not complete a ground path through grounded soldering irons. Before soldering on the Power Pack, remove the Pack from the Type 410 and disconnect the power cord.

2. Before disassembling or assembling the charger unit, disconnect the two wires leading to the plus and minus terminals of the battery.

3. Only after the circuit board is in a stable position with no shorts to the metallic parts should the leads be reconnected to the plus and minus terminals for troubleshooting or assembly.

Remove the 6 large screws that pass completely through the battery pack. See Fig. 4-10.

With the pack lying flat with the power cord receptacle up, remove the two screws that fasten to the hex. studs on the transformer. See Fig. 4-10.

Carefully lift the top half straight up (see Fig. 4-11) away from the bottom. The batteries and the bottom of the circuit board are now exposed.

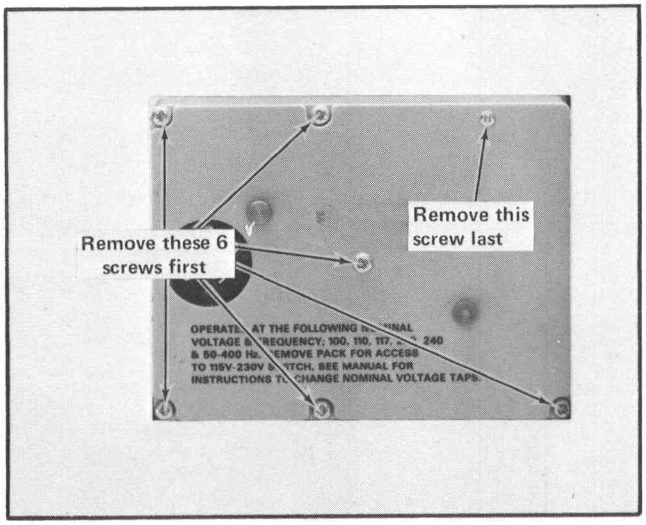


Fig. 4-10. Location of screws in the Battery Pack.

Fig. 4-11. Separation of the two sections of the Battery Pack.

Should the circuit board have to be removed for component replacement, proceed as follows:

016-0107-00 Models 1 and 2

Unsolder the five transformer leads from the end of the circuit board. Flex the transformer leads as little as possible to avoid lead breakage.

Remove the two square pin connectors from the board.

At the transformer lead end of the board, lift the board free of the two hexagonal standoff posts. Slide the board away from the support tab near the large capacitor and

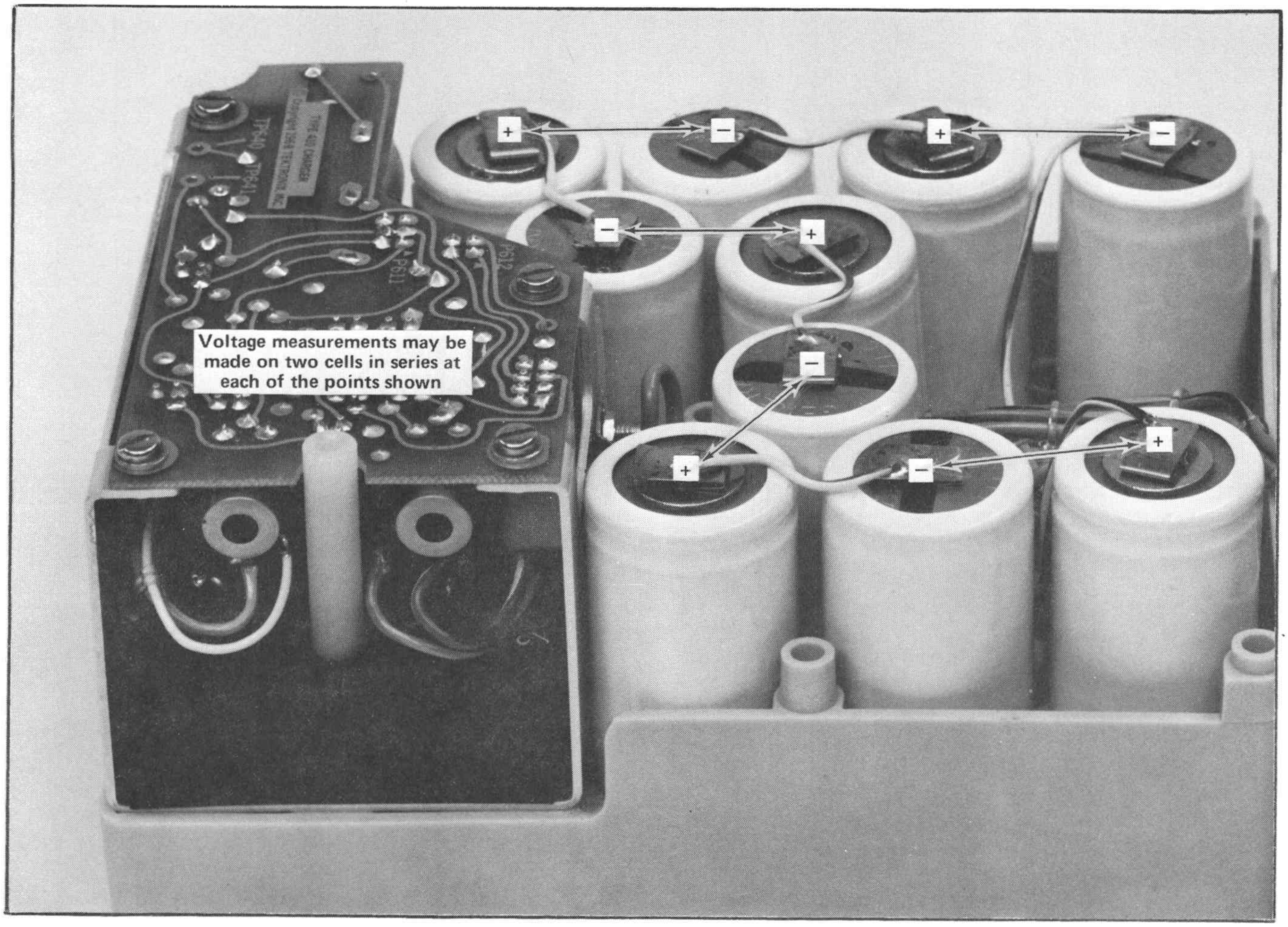


Fig. 4-12. Test points for cell isolation.

raise far enough to reach the remaining (four) square pin connectors. Remove the four connectors from the square pins and remove the board.

016-0107-02 All Models

Remove the four screws securing the circuit board to the chassis.

Carefully lift the circuit board away from the chassis. Unplug the two multiple-pin connectors.

Replacing the Nickel-Cadmium Cells. The battery should be working into a normal load while measuring cell voltages. Connect the battery pack to the Type 410, using the three 18-inch cords with banana plugs on both ends.

Cells may be isolated two at a time to measure cell voltage. See Fig. 4-12. To isolate a single cell, extend the cells outside the battery pack by soldering longer wire leads to the cells.

CAUTION

Be very careful when soldering to avoid heat damage to the cell cases and the nylon seal. Heat the terminal only long enough to complete a good solder joint. Avoid dropping the cells or any rough handling which might dent the case.

Single cells may be replaced if all of the cells in the pack are relatively new (not near the end of their useful life). If the cells have been in use over a period of years, replacement of all cells is recommended.

Transistor and FET Replacement

Transistors and FETs should not be replaced unless actually defective. If removed during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors or FETS may affect the calibration of this instrument. When transistors or FETS are replaced, check the operation of that part of the circuit that may be affected.

Replacement transistors or FETs should be of the orignal type, or, if the part has been selected by Tektronix for special characteristics, by Tektronix part number. (Consult the Electrical Part List, Section 7.)

The transistors should be mounted in the same manner as the orignal ones.

Fuse Replacement

The fuses for both the power line and the DC load are contained inside the battery pack. The use and ratings are shown in Table 4-2.

TABLE 4-2

Use	Rating
DC load (in battery pack)	5 A
[1]AC line (in battery pack)	100 mA

[1]One fuse in series with each transformer primary on 115 volt range.

Two spare fuses of each of the two sizes, 5A and 100 mA are supplied. They are located under the lid marked "fuses" in the upper half of the battery box. See Fig. 4-13.

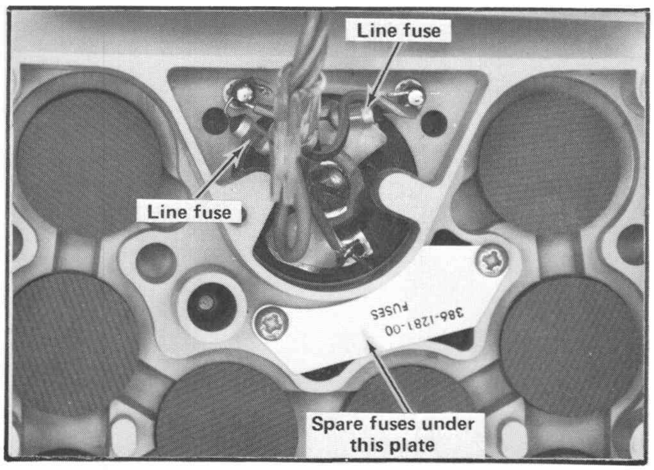


Fig. 4-13. Location of line fuses on the Power Receptacle.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 410. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in Section 9. The circuit number and electrical value of each component in this instrument are shown on the diagrams. Important voltages and waveforms are also shown on the diagrams.

Component Numbering. The circuit number of each electrical part is shown on the circuit diagram. Each main circuit is assigned a series of circuit numbers. Table 4-3 lists the main circuits in the Type 410 and the series of circuit numbers assigned to each. For example, using Table 4-3 a resistor numbered R212 is identified as being located in the Vertical Amplifier.

TABLE 4-3

Circuit Numbers on Schematics	Circuit
1-99	Connectors and Switching
100-299	Vertical Amplifier
300-499	Horizontal and Audio
500-599	CRT
600-699	Power Pack

Rotary Switches. Individual wafers or mechanical parts of rotary switches are normally not replaced. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

When replacing a switch, it is recommended that the leads and switch terminals be tagged with corresponding identification tags as the leads are disconnected. Then use the old switch as a guide for installing the new one. An alternative method would be to draw a sketch of the switch layout and record the wire color at each terminal.

Switch Wafer Identification. Switch wafers shown on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters "F" and "R" indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

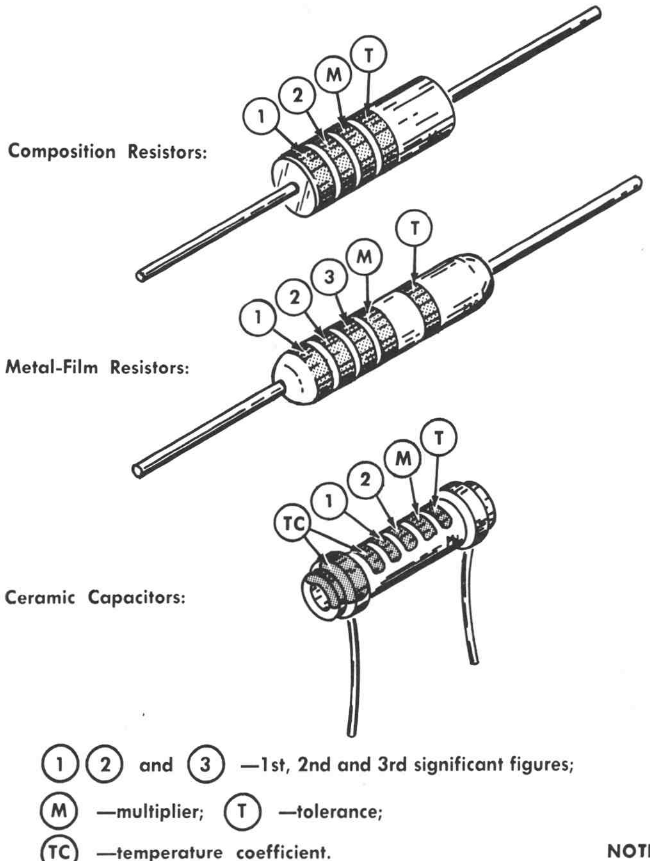
Circuit Boards

Figs. 4-15 through 4-20 at the end of this section show the circuit boards used in the Type 410. Each electrical component on the boards is identified by its circuit number. The circuit boards are also outlined on the schematic diagrams with a blue line. These pictures, used along with the diagrams, will aid in locating the components mounted on the circuit boards.

Capacitor Markings. The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in this instrument are color coded in picofarads using a modified EIA code. See Fig. 4-14.

Resistor Color Code. A number of precision metal film resistors are used in this instrument. These resistors can be identified by their gray body color. If a metal film resistor has a value indicated by three significant figures and a multiplier, it will be color coded according to the EIA standard resistor color code. If it has a value indicated by four significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333 kΩ resistor will be color coded, but a 333.5 kΩ resistor will have its value printed on the resistor body. The color code sequence is shown in Fig. 4-14.

Composition resistors are color coded according to the EIA standard resistor color code.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^2	10^2	±2%	±2%
Orange	3	10^3	10^3	±3%	±3%
Yellow	4	10^4	10^4	±4%	+100% −0%
Green	5	10^5	10^5	±0.5%	±5% or 0.5 pF*
Blue	6	10^6	10^6	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

***For capacitance of 10 pF or less.**

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 4-14. Resistor and ceramic capacitor color code.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation, and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given in this section.

1. Check Associated Test Equipment. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

2. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. For example, incorrect setting of the VERTICAL SIZE control appears as incorrect gain, etc. If there is any question about the function or operation of any control, see the Operating Instructions section of this manual.

3. Check Instrument Calibration. Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration section of this manual. Individual calibration steps can be performed out of sequence. However, if the circuit affects the calibration of other circuits in the instrument, a more complete calibration will be necessary. General Information in the Calibration section describes how calibration steps that interact are noted.

4. Isolate trouble to a Circuit. Table 4-6 lists some checks to make if no spot or trace is seen on the CRT.

Table 4-5 lists the three Input functions, the sensitivity for each function, and the operating mode of the Trigger Multivibrator for each function. Other information that may be useful for troubleshooting is also included in the table.

Incorrect operation of all circuits often indicates trouble in the power supply or low battery voltage. However, a defective component elsewhere in the instrument can appear as a power supply trouble and may also affect the operation of other circuits.

The pin connectors used to connect the etched wiring boards to the instrument provide a unique means of circuit isolation. For example, a defective component that causes excess current drain on a power supply may be isolated by disconnecting that voltage from each circuit board, in turn, until the circuit in trouble is located.

NOTE

When disconnecting battery from a circuit board, disconnect both the negative and positive 6.7 volts to protect the semiconductors in the circuit.

TABLE 4-5

Function	Input Sens[1]	Trigger Multivibrator	Audio	Transducer Power	Isolated Switch Contacts
EEG	10 mm/50 μV (50 μV/cm)	Astable (free running sweep)	No	No	Open
ECG	20 mm/mV (0.5 mV/cm)	Monostable (triggered sweep) Becomes astable after a signal loss.	Yes	No	Closed
AUX	2 mm/mV (5 mV/cm)[2]	Monostable (triggered sweep) Becomes astable after a signal loss.	Yes	Yes	Closed

[1]The input sensitivity is the input signal amplitude to which the Vertical Amplifier will respond to produce the current for one centimeter of CRT deflection. The yoke coils require about 15 mA per centimetre; this current is the result of a 50 μV signal amplitude in EEG, 0.5 mV in ECG, and 5 mV in AUX. It is a function of the Gain Selection Amplifier stage to provide the correct amplifier gain for each signal.

[2]Values approximate, with VERTICAL SIZE control in CAL detent. See page 1-1, Characteristics.

TABLE 4-6

TROUBLESHOOTING CHECKS

Symptom	Points to Check	Aids
No light on CRT	Battery voltage—6 to 7.5-volt per side. Voltage imbalance, 0.5 side to side.	
	+17-volt supply	Oscillator not running. Should run at approx. 1/3 amplitude with Q507 & Q510 removed
	+3650-volt supply	
	—50-volt supply	
	+175-volt supply	
	CRT grid bias (with 10 MΩ meter)	Meter loading may turn on CRT if Q560 is defective.
	Beam deflection off screen	Unplug yoke connections (to isolate to horiz. or vert.)

Table 4-7 lists the tolerance of the power supplies in the Type 410. If a power supply voltage is within the listed tolerance the supply can be assumed to be working correctly. If outside the tolerance, the supply may be operating incorrectly.

After a defective circuit has been located, proceed with steps 5 through 8 to locate the defective component(s). If the trouble has not been isolated to a circuit using the procedure described here, check voltages and waveforms as explained in Step 7 to locate the defective circuit.

TABLE 4-7

POWER SUPPLY TOLERANCES

Power Supply	Tolerance	Range	
—11.4 V	7.5%		
—6.7 V		5.85 to 7.5	May go higher on charge with no load
+6.7 V		5.85 to 7.5	
+17.0 V	±5%		

5. Check Circuit Board Interconnections. After the trouble has been isolated to a particular circuit check the pin connectors on the etched wiring board for correct connection. Figs. 15 through 20 show correct connections.

6. Visual Check. Visually check the circuit in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged etched wiring boards, or damaged components.

7. Check Voltages and Waveforms. Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the Schematic Diagrams.

NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly from instrument to instrument (the —6.7 and +6.7 will vary according to the charge condition of the batteries). To obtain operating conditions similar to those used to take these readings, see the first Schematic page.

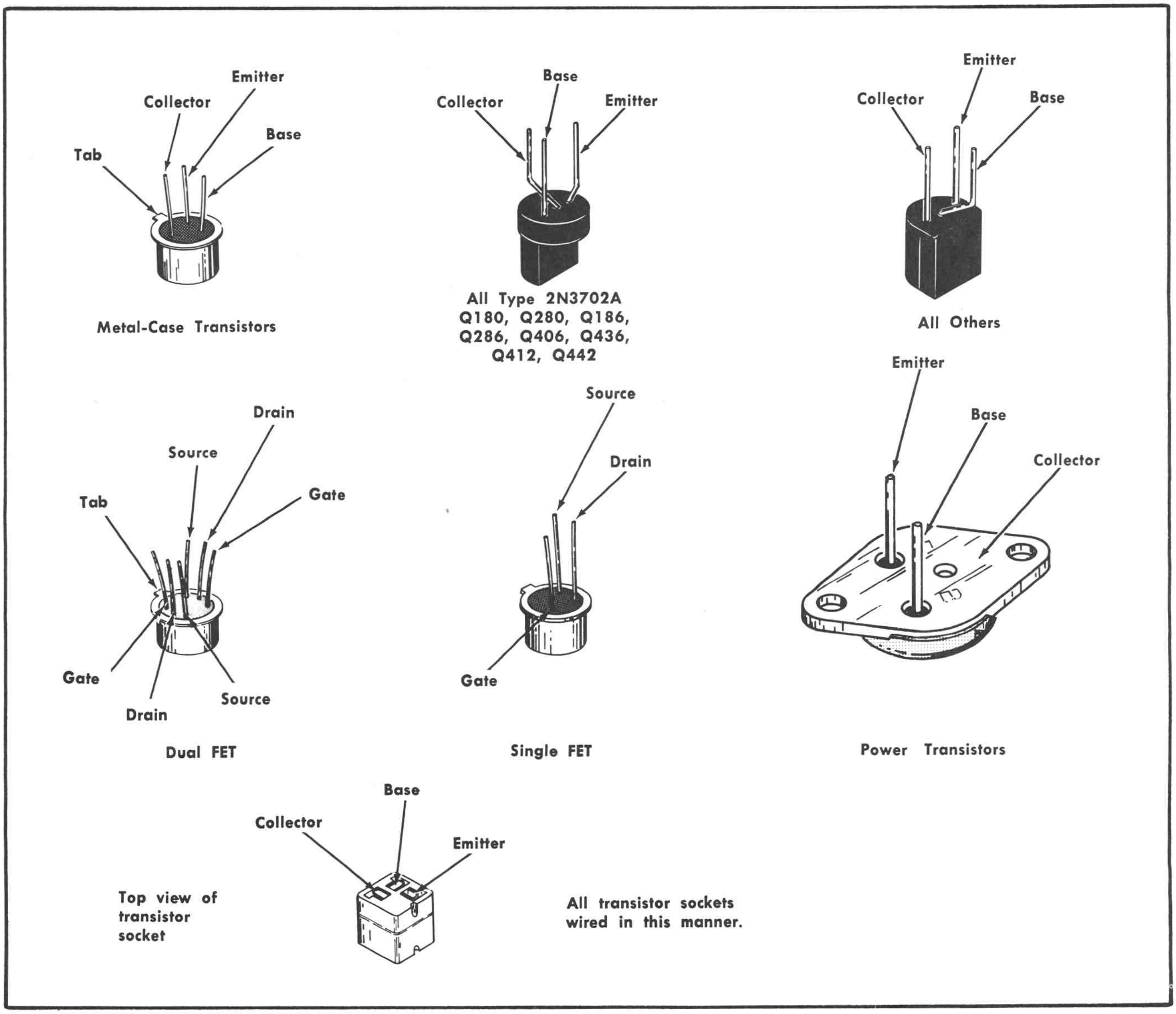


Fig. 4-15. Semiconductor base pin and socket arrangements.

A. Voltages. Voltage measurements should be taken with a voltohmmeter having a resistance of at least 20,000 ohms per volt. Accuracy of the voltmeter should be within ±2% on all ranges. Be sure that the test prods are well insulated to prevent accidental short circuit of components.

B. Waveforms. Use a test oscilloscope that has the following minimum specifications: Bandwidth, 0.5 MHz; deflection factor, 1 mV per division; input resistance, approximately 10 MΩ paralleled by about 10 pF when using a 10× probe.

8. Check Individual Components. The following procedures describe methods of checking individual components in the Type 410. Components that are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurement due to the effects of surrounding circuitry.

A. Transistors and FETs. The best check of transistor or FET operation is actual performance under operating conditions. If a transistor or FET is supected of being defective it can best be checked by substituting a new component or one that has been checked previously. However, be sure that the circuit conditions are not such that a replacement transistor or FET might also be damaged. If substitute transistors or FET's are not available a dynamic tester (such as the Tektronix Type 576) may be used. Static type testers are not recommended since they do not simulate operating conditions. Fig. 4-15 shows transistor and FET base pin configurations used in this instrument.

B. Diodes (except input Field-effect diodes). A diode can be checked for an open or short circuit condition by measuring the resistance between terminals. Using an ohmmeter scale having an internal source of about 1.5 volts, the resistance should be very high in one direction and very low when the meter leads are reversed.

CAUTION

Do not check Field Effect Diodes with an ohmmeter, and do not use an ohmmeter scale that has a high internal current for other diode types.

C. Resistors. Resistors (other than the 1% types) can be checked with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this instrument.

D. Capacitors. A leaky or shorted capacitor may be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor.

An open capacitor may be checked with a capacitance meter or by checking whether the capacitor passes AC signals.

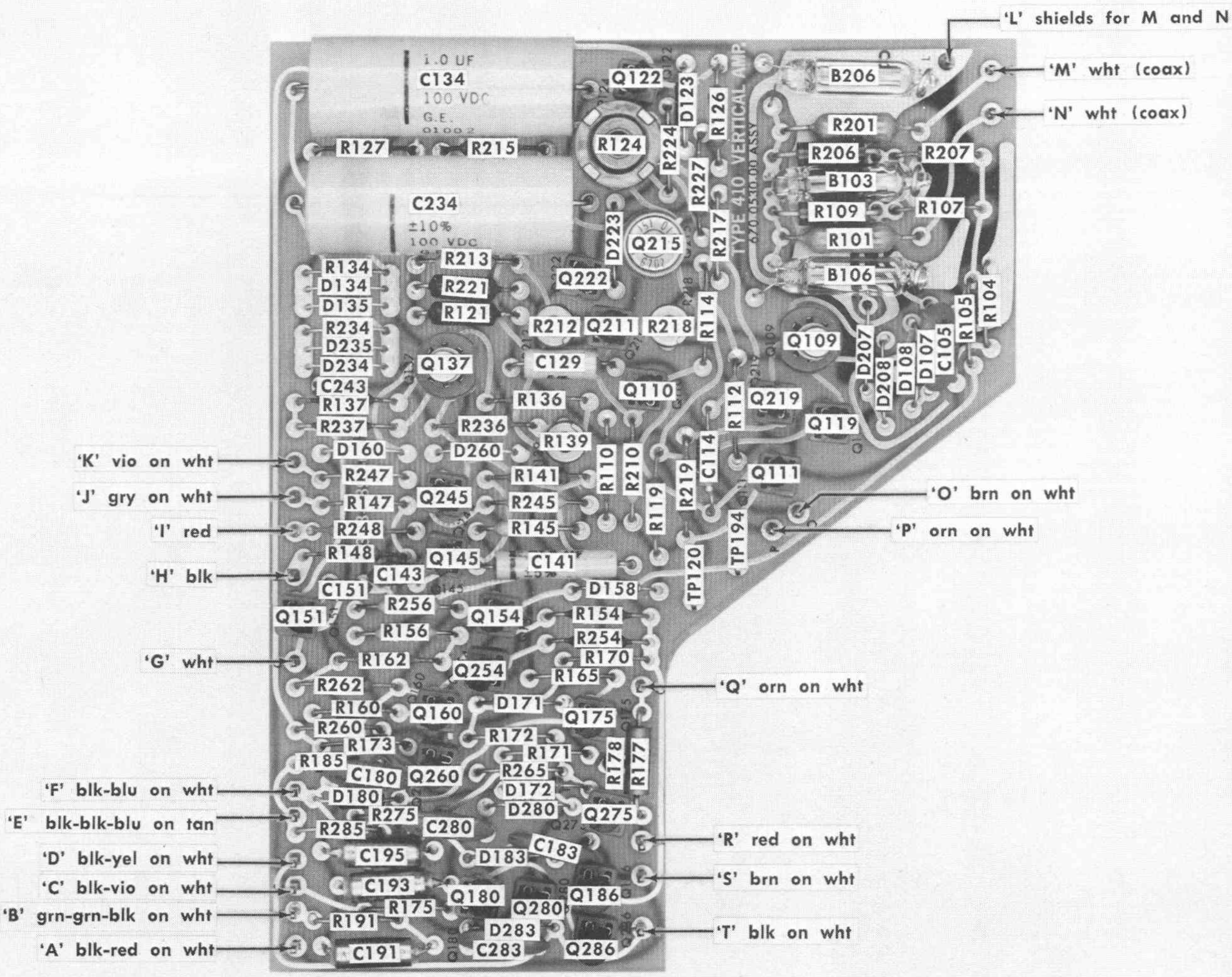
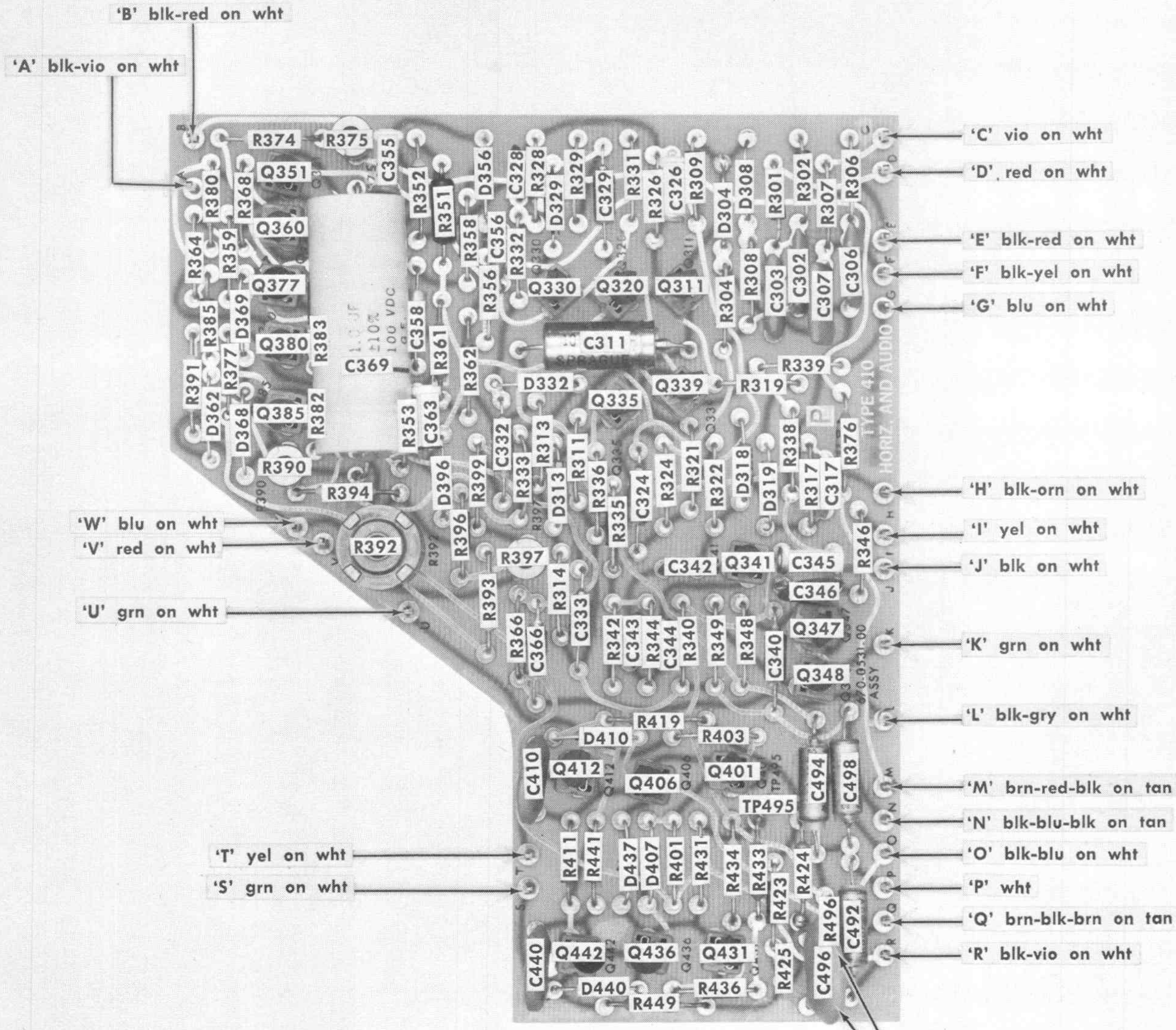


Fig. 4-16. Vertical Circuit Board.



SN B101215 and up:

Remove C496 and R496 and replace R496 with a 22 gauge bare wire strap.

Fig. 4-17. Horizontal and Audio Circuit Board.

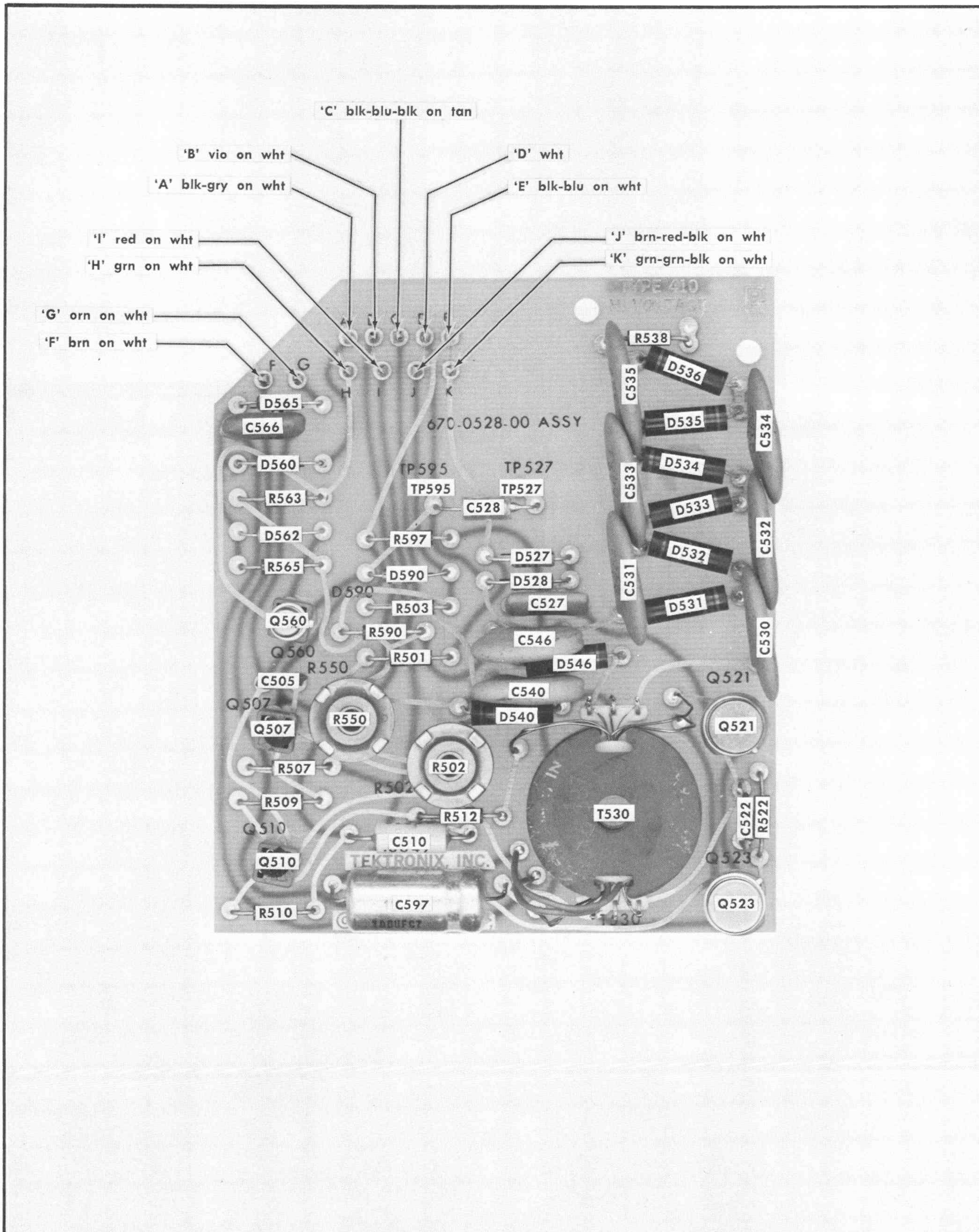


Fig. 4-18. High Voltage Circuit Board.

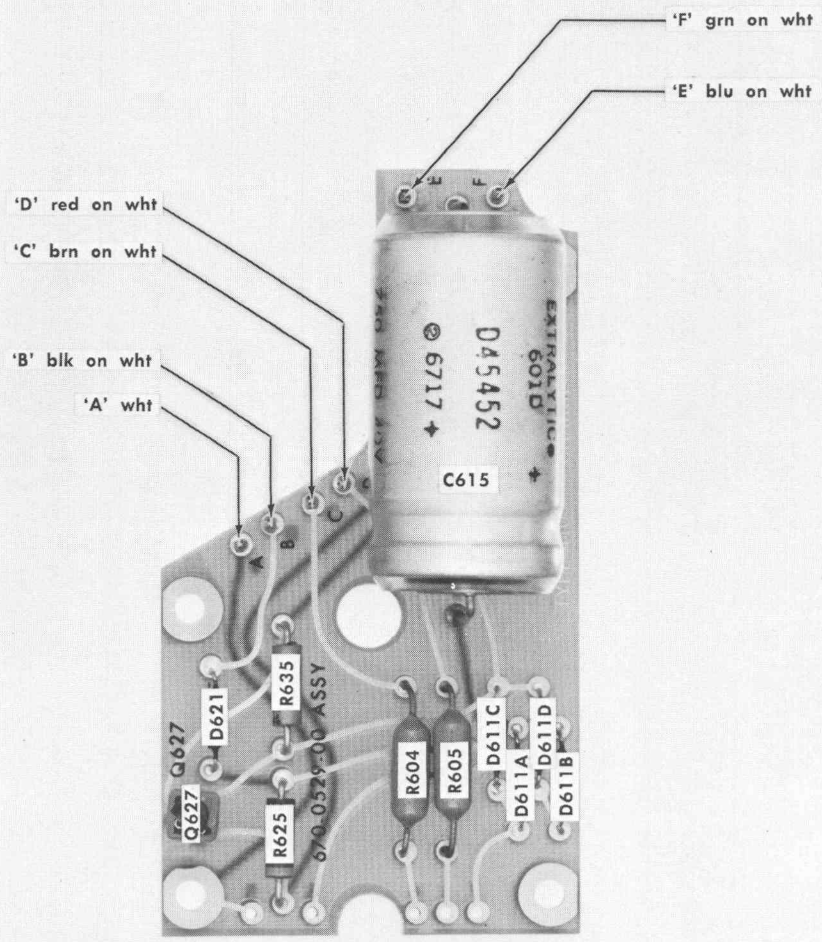


Fig. 4-19. Battery Charger Circuit Board. Battery Pack 016-0107-00, Models 1 and 2.

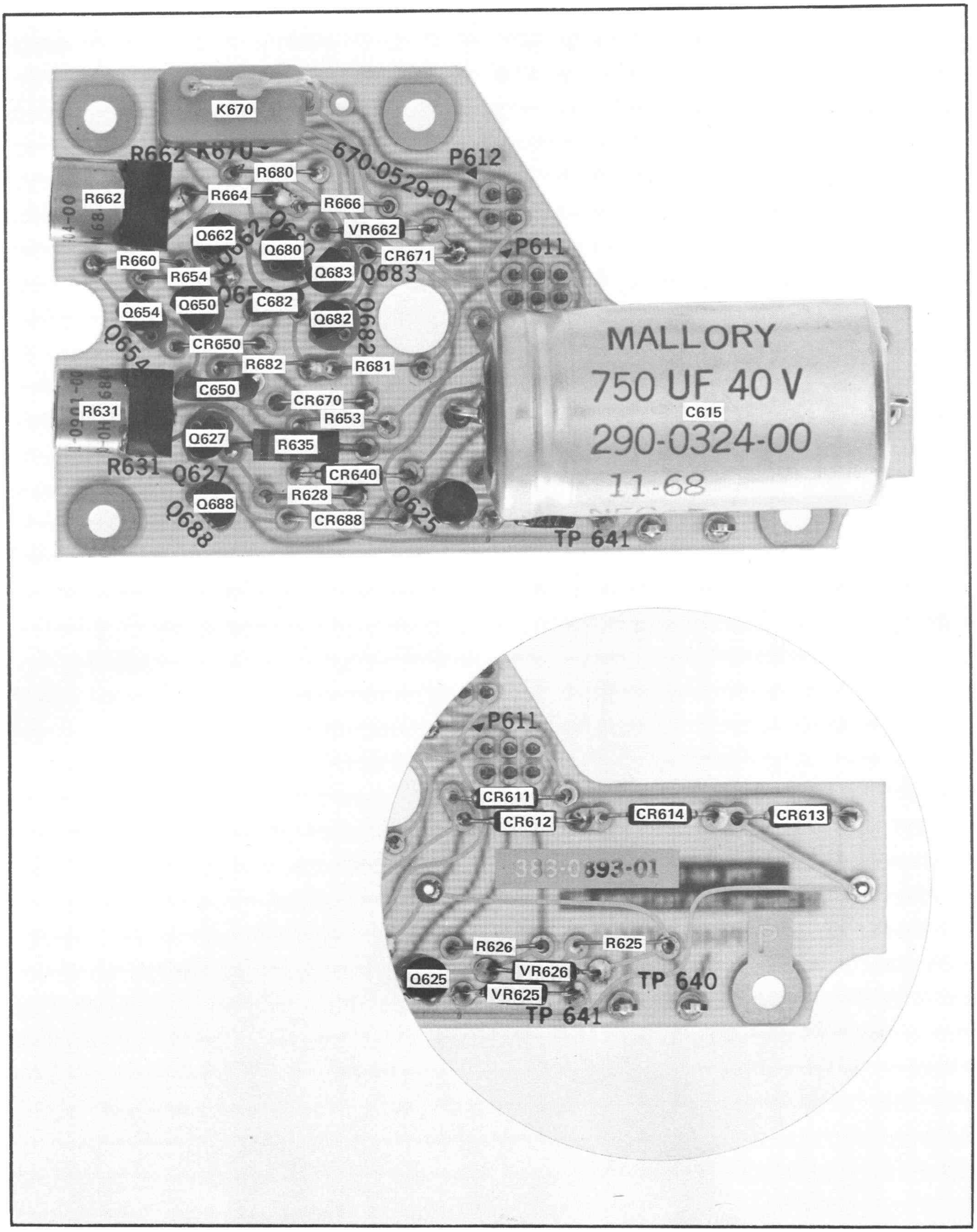


Fig. 4-20. Battery Charger Circuit Board. Power Pack 016-0107-02, Model 1, 2, and 3.

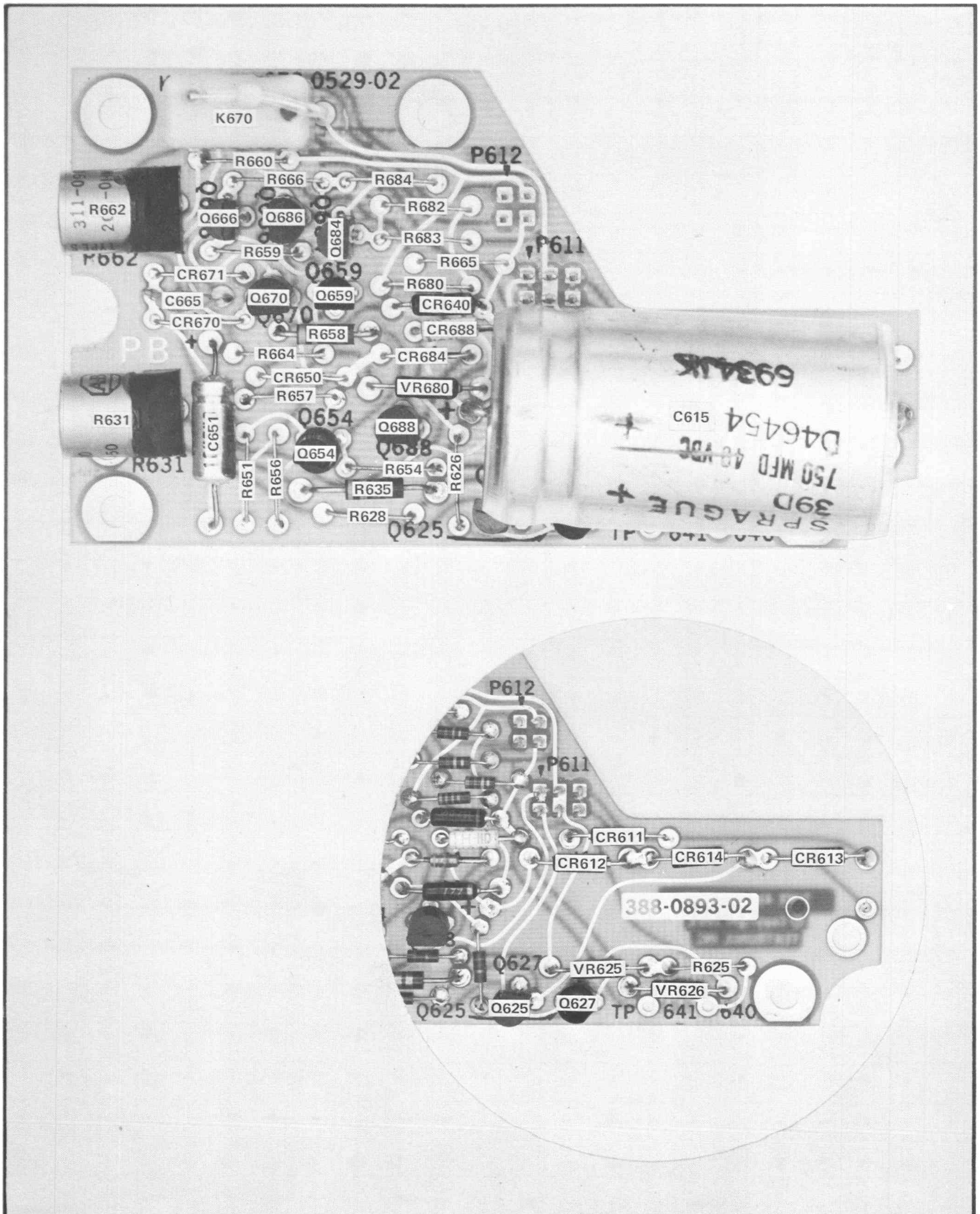


Fig. 4-21. Battery Charger Circuit Board. Power Pack 016-0107-02, Models 4 and up.

NOTES

SECTION 5
PERFORMANCE CHECK

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

This section of the manual provides a means of rapidly checking the performance of the Type 410. It is intended to check the calibration of the instrument without the need for performing the complete Calibration Procedure. The Performance Check does not provide for the adjustment of any internal controls. Failure to meet the requirements given in this procedure indicates the need for internal checks or adjustments, and the user should refer to the Calibration Procedure in this manual.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Input Adapter. Allows test signals to be applied to the Type 410. Tektronix Part No. 067-0549-00.

2. Power Supplies. Must be capable of supplying outputs variable from ± 5.95 volts to ± 6.7 volts, and ≥ 200 mA. For example, Try-gon Dual Lab Supplies Type DL40-1.

3. Test oscilloscope. Bandwidth DC to 500 kHz. Tektronix Type 561B with Type 3A3 Differential Amplifier and Type 2B67 Time Base recommended.

4. Sine-wave generator. Frequencies, 1 hertz to 290 hertz. Signal amplitude, variable from 0 to 10 volts peak to peak. For example, Krohn-Hite 440A.

5. Standard amplitude calibrator. Amplitude accuracy, within 1.0% signal amplitude, 0 to 100 volts; output signal +DC and —DC; must have mixed display feature. Tektronix calibration fixture 067-0502-00 recommended.

6. Time-mark generator. Marker outputs, 0.1 second to 1 second; accuracy 0.1%. Tektronix 2901 Time-Mark Generator recommended.

7. Binding post adapter, BNC Dual Binding Post. Tektronix Part No. 103-0035-00.

8. Patch cords (4). Length, 18 inches. Banana plugs on both ends. Tektronix Part No. 012-0031-00.

9. Patch cord. Length, 6 inches. Banana plugs on both ends. Tektronix Part No. 012-0024-00.

10. 10× probe with BNC connector. Tektronix P6006 Probe recommended. Tektronix Part No. 010-0127-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Recommended Equipment. If substitute equipment is used, control settings or setups must be altered to meet the requirements of the equipment used.

Preliminary Procedure

1. Set the SWEEP SPEED selector to POWER OFF.

2. Remove "Pop" cover and Battery Pack.

3. Connect the Input Adapter to the Type 410 Patient Cable connector.

4. Set test power supply outputs to + and — 6.7 volts and conect to the Type 410 power supply input terminals. Connect the power supply common ground to the Type 410 circuit ground terminal.

5. Set the controls as follows:

Type 410

INPUT SELECTOR	ECG
SWEEP SPEED	50 mm/s
VERTICAL SIZE	CCW
VERTICAL POSITION	Midrange
ECG LEAD SELECTOR	I
LOUDNESS	CCW

Input Adapter

+(ATTEN)	×10,000
—(ATTEN)	×10,000
CM ON	OFF
MODE	BAL
INPUT SELECTOR	ECG
ECG LEAD SELECTOR	I

1. Check Vertical Size Balance

REQUIREMENT—Trace shift is ≤ 1.5 cm.

a. Check for minimum trace shift while rotating the VERTICAL SIZE control throughout its range.

b. CHECK—Trace shift is $\leq$1.5 cm.

2. Check Calibrated Deflection Sensitivity

REQUIREMENT—Correct deflection for EEG, ECG and AUX.

a. Connect the standard amplitude calibrator output to the Input Adapter (+) INPUT, using a binding post adapter and a patch cord. Connect a patch cord between the binding post adapter ground terminal and the Input Adapter ground terminal.

b. Rotate the VERTICAL SIZE control to its detent (CAL) position and set the standard amplitude calibrator for a 20-volt +DC mixed output.

c. CHECK—4 centimeters, $\pm$0.2 cm, of vertical display. See Fig. 5-1B.

d. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG.

e. Set the standard amplitude calibrator for a 2-volt +DC mixed output.

f. CHECK—4 centimeters, $\pm$0.2 cm, of vertical display.

g. Set the Type 410 and Input Adapter INPUT SELECTOR switches to AUX.

h. Set the standard amplitude calibrator for a 100-volt +DC mixed output.

i. CHECK—2 centimeters, $\pm$0.2 cm, of vertical display.

3. Check Vertical Size Range

REQUIREMENT— $\leq$ 1/3 to $\geq$ 3 times the signal amplitude obtained in CAL.

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

b. Rotate the VERTICAL SIZE control fully counterclockwise and set the standard amplitude calibrator for a 20-volt +DC mixed output.

c. CHECK—$\leq$1.3 centimeters of vertical display (1/3 of the 4 cm obtained in CAL $\approx$1.3 cm) as shown in Fig. 5-1C.

d. Rotate the VERTICAL SIZE control fully clockwise and set the standard amplitude calibrator for a 10-volt +DC mixed output.

e. CHECK—$\geq$6 centimeters of vertical display ($\geq$3 times the 2 cm display amplitude obtained in CAL) as shown in Fig. 5-1A.

f. Remove the standard amplitude calibrator signal from the Input Adapter.

4. Check Amplifier Noise

REQUIREMENT—Periodic and random deviations must not exceed 0.1 cm.

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG.

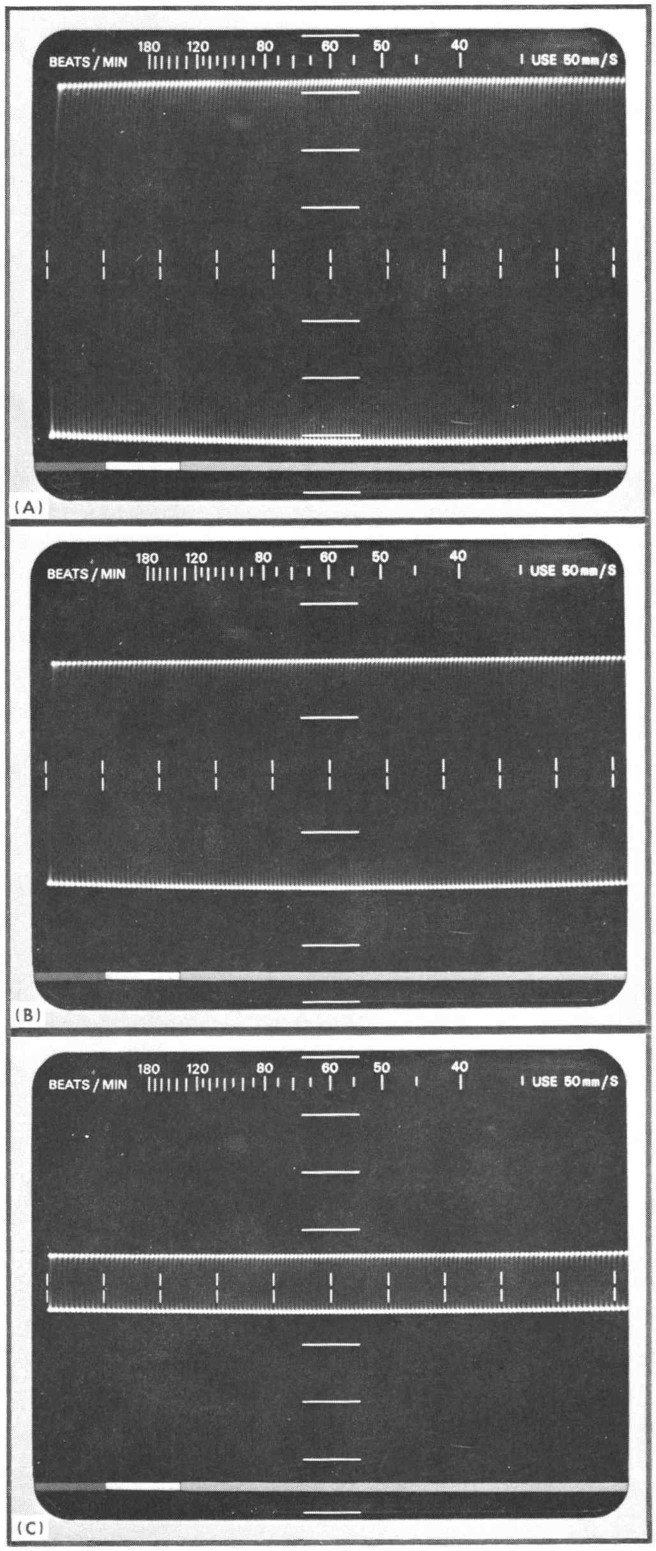


Fig. 5-1. Typical CRT displays when checking vertical gain.

b. Set the VERTICAL SIZE control to its detent (CAL) position.

c. Connect a short patch cord between the Input Adapter (+) and (—) INPUTS.

d. CHECK—Peak to peak noise does not exceed 0.1 cm of vertical display (subtract normal trace width).

e. Remove the patch cord from the Input Adapter (+) and (—) INPUTS.

5. Check Common Mode Dynamic Range

REQUIREMENT—Common-mode dynamic range is at least + and — 3 volts.

a. Connect the sine-wave generator output to the Input Adapter C.M. IN connector with a patch cord. Connect a patch cord between the ground terminals of the Input Adapter and the sine-wave generator.

b. Connect the + input of the test oscilloscope, through a 10X probe, across the Output of a sine-wave generator. Set the oscilloscope controls as follows:

Vertical (Channel 1)

(+) Input Coupling	DC
(—) Input Coupling	GND
Mode	CH 1
Trigger	CH 1
Volts/Division	0.5 Volts

Horizontal

Triggering	Level	Midrange
	Slope	+
	Coupling	AC Slow
	Source	Int
Mode		Normal
Time/Division		10 ms

c. Set the sine-wave generator for a test oscilloscope display of 1 division (5 volts peak to peak) at 60 hertz. Adjust the Triggering Level control for a stable display.

d. Place the Input Adapter C.M. ON switch to its ON (left) position.

e. While viewing the Type 410 display, slowly increase the sine-wave generator signal amplitude until the display begins to increase rapidly.

f. CHECK—Test oscilloscope display amplitude is $\geq$1.2 divisions ($\geq$6 volts peak to peak). This indicates a common-mode dynamic range of + or — 3 volts or more.

g. Reset the sine-wave generator for a test oscilloscope display of 1 division (5 volts peak to peak) at 60 hertz.

6. Check Common Mode Rejection Ratio (0 Ω Source Impedance Unbalance)

REQUIREMENT—CMRR is $\geq$500,000:1.

a. The Type 410 and Input Adapter INPUT SELECTOR switches should be in EEG; the VERTICAL SIZE control should be in CAL.

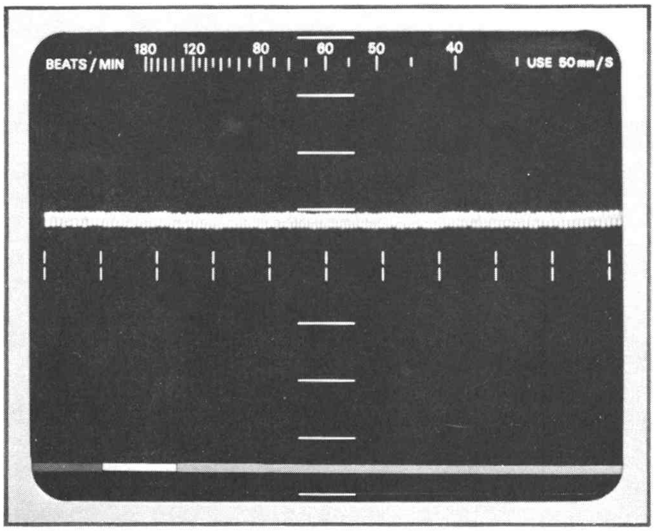


Fig. 5-2. Typical CRT display when checking CMRR (0 Ω Source Impedance Unbalance).

b. CHECK—The Type 410 display amplitude is $\leq$2 mm (CMRR of $\geq$500,000:1, or $\leq$10 μV of a 5-volt signal). See Fig. 5-2.

7. Check Common Mode Rejection (5 kΩ Source Impedance Unbalance)

REQUIREMENT—CMRR is $\geq$500,000:1.

a. Switch the Input Adapter Mode to + Unbal.

b. CHECK—Type 410 display amplitude should be equal or exceed 0.67 cm (CMRR of $\geq$150,000:1).

c. CHECK—CMRR with the Type 410 and Input Adapter Selector switches in ECG and EEG. Common-Mode Rejection should be $\geq$150,000:1.

d. Switch the Input Adapter Mode to —Unbal and repeat steps b and c.

8. Check Common Mode Rejection Ratio With 100 mV DC Offset

REQUIREMENT—CMRR is $\geq$150,000:1.

a. With the sine-wave generator connected as in steps 5 and 6, connect the standard amplitude calibrator output to the Input Adapter (—)INPUT, using a binding post adapter and a patch cord. Connect a patch cord between the ground terminals of the binding post adapter and the Input Adapter.

b. Set the Input Adapter (—)ATTEN switch to ×1000.

c. Set the standard amplitude calibrator for a 100-volt +DC output (not mixed).

d. CHECK—Type 410 display amplitude is $\leq$0.67 centimeter (indicates a CMRR of at least 150,000:1 with +100 mV DC offset).

e. Set the standard amplitude calibrator for a 100-volt —DC output.

f. CHECK—Type 410 display amplitude is $\leq$0.67 centimeter (indicates a CMRR of at least 150,000:1 with —100 mV DC offset).

9. Check Gain With 100 mV DC Offset

REQUIREMENT— $\leq$5% loss in gain with 100 mV DC offset.

a. Move the sine-wave generator signal from the Input Adapter C.M. IN connector to the (+)INPUT connector.

b. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

c. Set the standard amplitude calibrator for a zero-volt output and adjust the sine-wave generator for a 6-centimeter display at 10 hertz (see Fig. 5-3).

d. Set the standard amplitude calibrator for a 100-volt +DC output.

e. CHECK— $\geq$5.7 centimeters of vertical display (see Fig. 5-4).

f. Set the standard amplitude calibrator for a 100-volt —DC output.

g. CHECK— $\geq$5.7 centimeters of vertical display.

10. Check Overdrive Recovery Time

REQUIREMENT—Time required for return of usable display must be less than 4 seconds.

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG.

b. Adjust the sine-wave generator for a 2-centimeter display at 60 hertz (see Fig. 5-4).

c. Switch the standard amplitude calibrator from —DC to +DC.

d. CHECK—Time required for return of usable display.

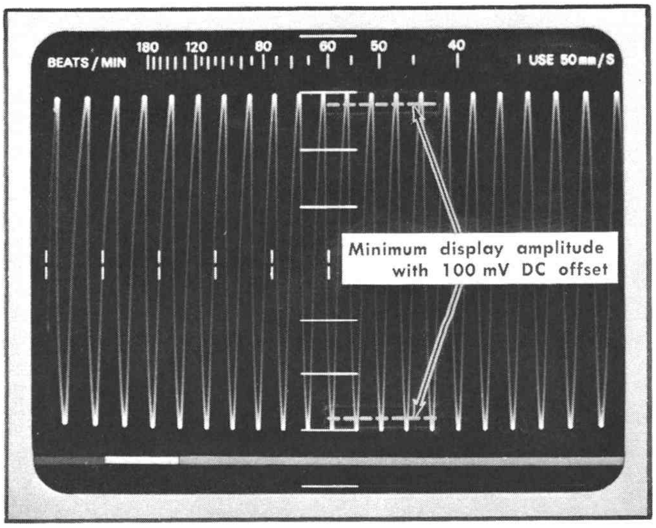


Fig. 5-3. Typical CRT display when checking gain with 100 mV DC offset.

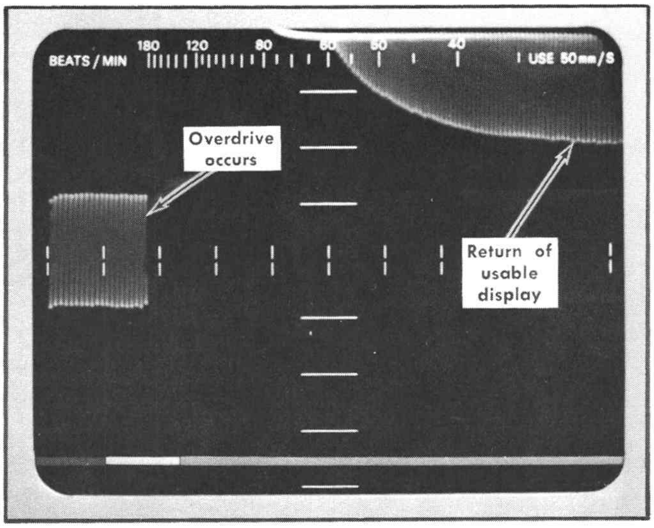


Fig. 5-4. Typical CRT display when checking overdrive recovery time.

e. Switch the standard amplitude calibrator from +DC to —DC.

f. CHECK—Time required for return of usable display must be less than 4 seconds.

11. Check Bandwidth High Frequency —3 dB Point

REQUIREMENT—Frequency at high frequency —3 dB is 100 Hz, ±15% for EEG; 250 Hz, ±15% for ECG and AUX.

a. Set the SWEEP SPEED selector to 25 mm/s.

b. Adjust the sine-wave generator for a 6-centimeter display at 20 hertz.

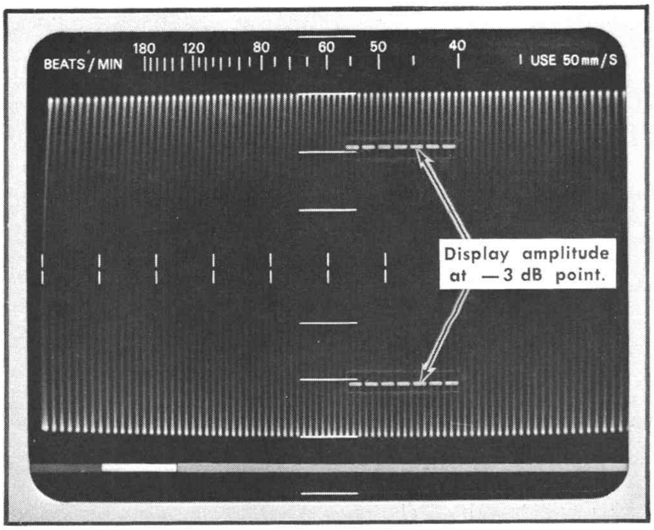


Fig. 5-5. Typical CRT display when checking high frequency —3 dB point.

c. With the display centered, slowly increase the sine-wave frequency until the display amplitude decreases to 4.2 centimeters. See Fig. 5-5.

d. Check—Frequency at —3 dB is 85 to 115 Hz for EEG.

e. Repeat steps b and c with the Type 410 and Input Adapter INPUT SELECTOR switches in ECG and AUX. (It may be necessary to place the Input Adapter (+) ATTEN switch to X100 when checking AUX. then return to X10,000.)

f. CHECK—Frequency at —3 dB is 212.5 to 287.5 Hz for ECG and AUX.

g. Disconnect the sine-wave generator.

12. Check Bandwidth Low Frequency —3 dB Point

REQUIREMENT—Frequency at low frequency —3 dB is $\leq$0.1 Hz.

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

b. Rotate the VERTICAL SIZE control fully clockwise.

c. Move the standard amplitude calibrator signal from the Input Adapter (—) INPUT connector to the (+) INPUT connector.

d. Set the standard amplitude calibrator for a 5-volt —DC output and position the trace to the third cm mark below graticule center (see Fig. 5-6).

e. Switch the standard amplitude calibrator from —DC to +DC.

f. CHECK—Trace must step to at least the third cm mark above graticule center and decay to graticule center in more than 1.1 seconds (see Fig. 5-6).

g. Disconnect all test equipment.

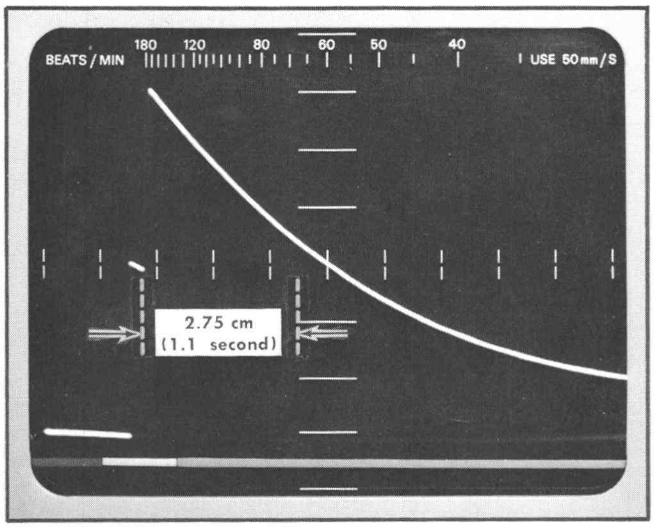


Fig. 5-6. Typical CRT display when checking low frequency —3 dB point.

13. Check Triggering Sensitivity (Slow Rise Signal)

REQUIREMENT—Triggering sensitivity is $\leq$0.5 cm.

a. Set the controls as follows:

Type 410

SWEEP SPEED	50 mm/s
VERTICAL SIZE	Fully ccw
VERTICAL POSITION	Midrange

Input Adapter

+(Atten)	X100
—(Atten)	X1000
CMR Test	Off
Mode	Bal

b. Connect the sine-wave generator to the (—) Input of the Type 410 Input Adapter with a patch cord.

c. Set the sine-wave generator frequency to 1 Hz then adjust its output for 0.5 volt peak-to-peak signal. (Use the test oscilloscope to measure the generator output.)

d. Rotate the loudness control clockwise until audio tones are heard. There should be one for each switching cycle of the trigger circuit. Triggering on both positive and negative slopes of the sinewave is normal.

e. Slowly decrease the input signal until triggering is lost. This is usually indicated by 6 to 10 audible notes per second followed by a free-running sweep.

f. CHECK—Loss of triggering (audio tone rate increases) should occur when trigger signal amplitude drops below 0.5 cm.

14. Check Triggering Sensitivity (Fast Rise Signal)

REQUIREMENT—Triggering Sensitivity $\leq$0.7 cm.

a. Insert the sine-wave generator output into the Trig Input jack on the Type 410 Input Adapter.

b. Set the generator frequency to 1 Hz and adjust its output.

c. Switch trigger test On at the Type 410 Input Adapter.

d. There should be one audible tone for each cycle appearing on the Type 410 CRT.

e. Slowly decrease input signal amplitude until audible tone rate changes.

f. Loss of triggering (indicated by increase in the audio tone rate) should occur when the trigger signal amplitude drops below 0.7 cm.

g. Rotate 'LOUDNESS' control ccw and disconnect all test equipment.

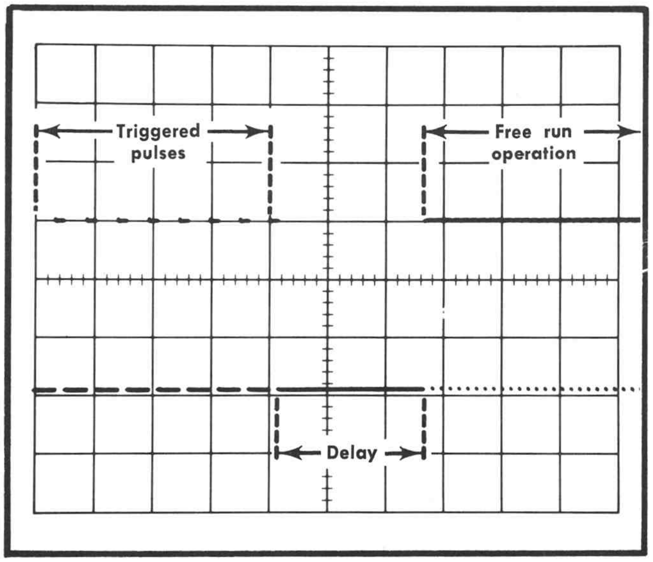


Fig. 5-7. Typical test oscilloscope display when checking sweep free run delay.

15. Check Sweep Free Run Delay

REQUIREMENT—Sweep free runs 2 to 4 seconds after last trigger.

a. Connect the time-mark generator marker output to the Input Adapter (+) INPUT, using a binding post adapter and a patch cord. Connect a patch cord between the binding post adapter ground terminals and the Input Adapter ground terminal.

b. Set the time-mark generator for 0.5-second markers.

c. Adjust the VERTICAL SIZE control for a triggered display on the Type 410.

d. Set the test oscilloscope controls as directed in step 5b. Change the Time/Division switch to 1 s.

e. Connect a 10X probe, from the test oscilloscope +Input connector to pin 4 of the OUTPUT connector at the rear panel of the Type 410.

f. While observing the display on the test oscilloscope, disconnect the time-mark generator signal from the Input Adapter (+) INPUT and note the length of time between the last trigger pulse and the astable operation of the Trigger Multivibrator.

g. CHECK—Sweep free run delay is between 2 and 4 seconds. See Fig. 5-7.

h. Remove the 10X probe.

16. Check Battery Check Cal

REQUIREMENT—Red to yellow transition, ±0.5 cm = 11.9 V Battery condition.

a. Change the SWEEP SPEED selector to BATTERY CHECK.

b. Set the testpower supply + output to +5.95 volts.

c. With the VERTICAL POSITION control, move the spot to a point near the colored scale in the lower screen area.

d. CHECK—Spot is positioned to the junction fo the red and yellow zones on the scale within 0.5 cm to right or left. See Fig. 5-8.

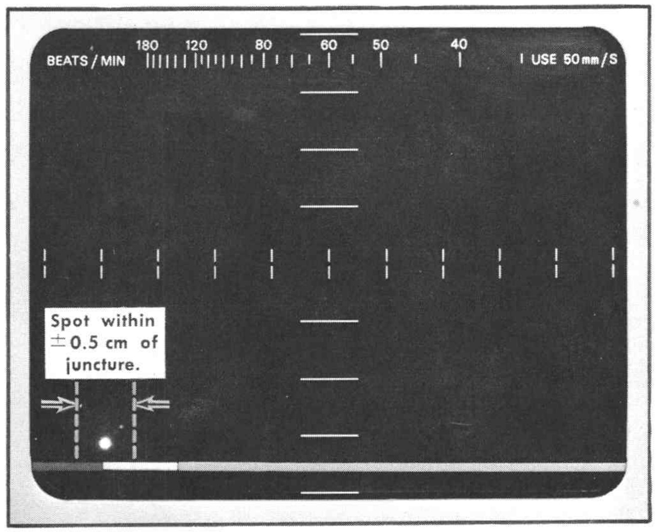


Fig. 5-8. Typical CRT display when checking Battery Check Cal.

17. Check Heart Rate Scale Accuracy

REQUIREMENT—Accuracy within ±5% of reading.

a. Set the test power supply + output to +6.7 volts.

b. Connect the time-mark generator marker output to the Input Adapter (+) INPUT and set the time-mark generator for 0.1-second and 0.5-second markers.

c. CHECK—The second and fourth 0.5-second markers should coincide, within ±5% of reading, with the 120 and 40 BEATS/MIN on the Heart Rate Scale. (It may be convenient to position the display with the VERTICAL POSITION control. After the check has been made, return the trace to graticule center).

18. Check Timing Accuracy

REQUIREMENT—Accuracy within ±5% at 25, 50 and 100 mm/s.

a. Set the time-mark generator for 1-second markers.

b. Note the distance between the first and last time markers for each SWEEP SPEED position.

c. CHECK—Distance noted in step b is 10 centimeters, ±0.5 cm, with the SWEEP SPEED selector in the 25, 50 and 100 mm/s position.

d. Disconnect all test equipment.

This completes the performance check procedure for the Type 410. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

SECTION 6
CALIBRATION

Change information, if any, affecting this section is found at the rear of the manual.

Introduction

This calibration procedure can be used either for complete calibration of the Type 410 to return it to original performance, or as an operational check of instrument performance. Completion of every step in this procedure returns the Type 410 to original factory performance standards. If it is desired to merely touch up the calibration, perform only those steps entitled adjust. . . .

NOTE

The adjust. . . steps provide a check of instrument performance before the adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met.

General Information

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section of the Instruction Manual.

This procedure is arranged in a sequence which allows this instrument to be calibrated with the least interaction of adjustments and reconnection of equipment. If desired, the steps may be performed out of sequence or a step may be done individually if the preceding step(s) are referred to for setup information.

In the lists of control settings, those controls which have been changed since the previous setup are shown in bold type.

The location of test points and adjustments is shown in each step. Waveforms which are helpful in determining the correct adjustment or operation are also shown.

EQUIPMENT REQUIRED
(See Fig. 6-1)

General

The following equipment, or its equivalent, is required for complete calibration of the Type 410. Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Special Test Equipment

For the quickest and most accurate calibration, special calibration fixtures listed under Equipment Required can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

Equipment Required

1. Input Adapter. Allows test signals to be applied to the Type 410. Tektronix Part No. 067-0549-00.

2. Power Supplies. Must be capable of supplying outputs variable from ±5.95 volts to ±6.7 volts, and ≥200 mA. For example, Try-gon Dual Lab Supplies DL 40-1.

3. Test osciloscope. Bandwidth DC to 500 kHz. Tektronix Type 561B with Type 3A3 Differential Amplifier and Type 2B67 Time Base recommended.

4. Electronic Voltmeter. Accuracy, within ±1.0% range, 0 to 200 volts. For example, General Radio Type 1806-A.

5. DC Voltmeter. Minimum sensitivity, 20,000 ohms/volt. Simpson 262 or Triplett 630.

6. Sine-wave generator. Frequencies, 1 hertz to 290 hertz. Signal amplitude, variable from 0 to 10 volts, peak to peak. For example, Krohn-Hite 440A.

7. Standard amplitude calibrator. Amplitude accuracy, within 1.0%; signal amplitude, 0 to 10 volts; output signal, +DC and —DC; must have mixed display feature. Tektronix calibration fixture 067-0502-00 recommended.

8. Time-mark generator. Marker outputs, 0.1 second to 1 second; accuracy 0.1%. Tektronix Type 2901 Time-Mark Generator recommended.

9. Binding post adapter, BNC Dual Binding Post. Tektronix Part No. 103-0035-00.

10. Patch cords (4). Length, 18 inches. Banana plugs on both ends. Tektronix Part No. 012-0031-00.

11. Patch cord. Length, 6 inches. Banana plug on both ends. Tektronix Part No. 012-0024-00.

12. 10× probe with BNC connector. Tektronix P6006 Probe recommended. Tektronix Part No. 010-0127-00.

13. Screwdriver. Three-inch shaft. Tektronix Part No. 003-0192-00.

14. Alignment Tool, Yoke (not shown). Tektronix Part Number 003-0600-00.

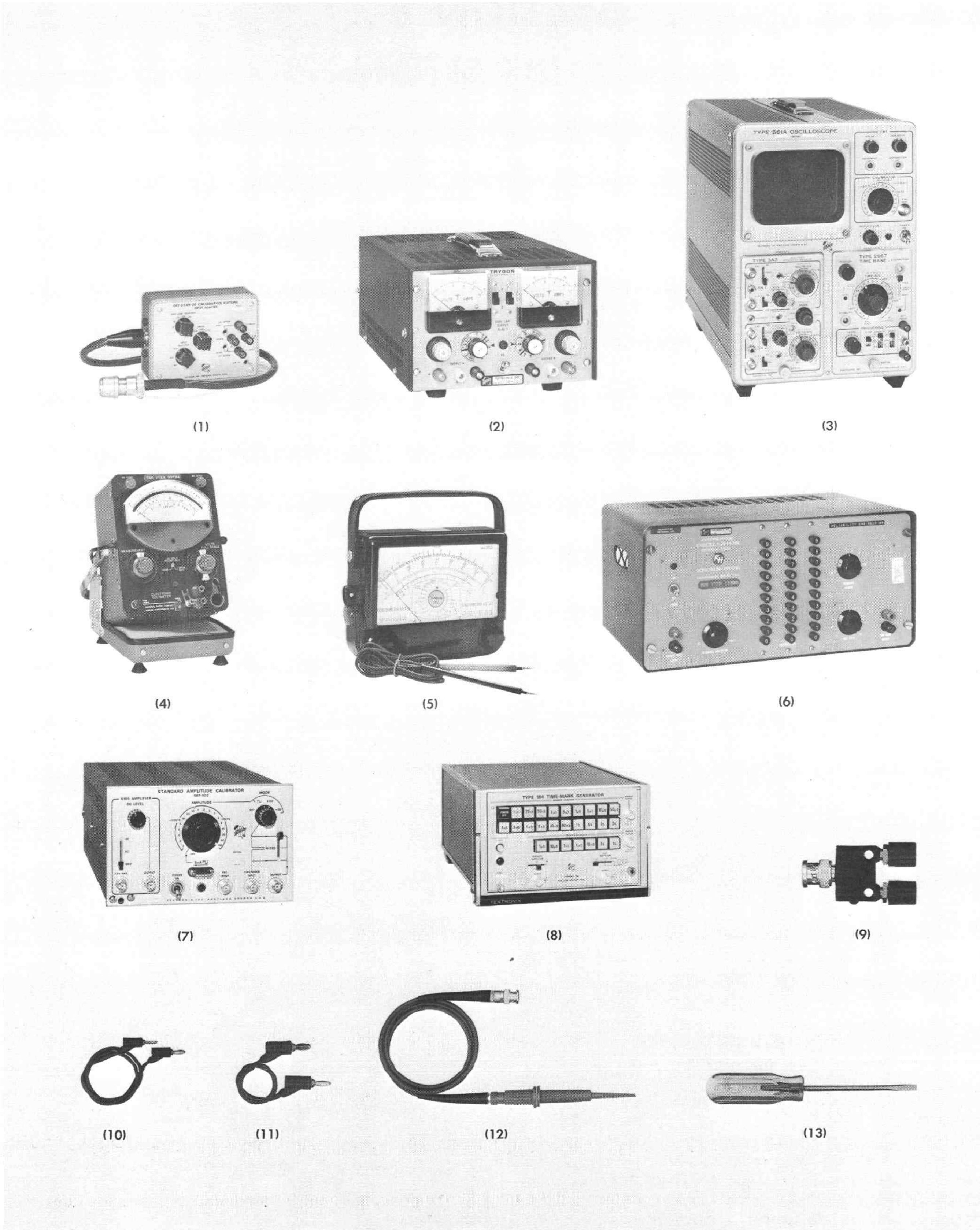


Fig. 6-1. Recommended calibration equipment.

CALIBRATION RECORD AND INDEX

This abridged Calibration Procedure is provided to aid in checking the operation of the Type 410. It may be used as a calibration record. Since the step numbers and titles used here correspond to those used in the complete Calibration Procedure, the following procedure serves as an index to locate a step in the complete Calibration Procedure. Characteristics are those listed in the Characteristics section of the Instruction Manual.

Type 410, Serial No. ____________________

Calibration Date ____________________

CALIBRATION PROCEDURE

General

In the following calibration procedure, a test equipment setup is shown for each major setup change. Complete control settings are listed following the picture. If only a partial calibration is performed, start with the nearest setup preceding the desired portion.

NOTE

When performing a complete recalibration, best performance will be provided if each adjustment is made to the exact setting, even if the Check is within the allowable tolerance.

The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary Procedure

1. Remove the Type 410 from its case (see disassembly in Section 4) to expose the internal controls and test points.

2. Connect the Input Adapter to the Type 410 Patient Cable connector.

3. Set the SWEEP SPEED selector to POWER OFF.

4. Set the test power supply outputs to + and — 6.7 volts and connect to the Type 410 power supply terminals. Connect the power supply common ground to the Type 410 circuit ground terminal.

5. Set the SWEEP SPEED selector to 50 mm/s.

NOTES

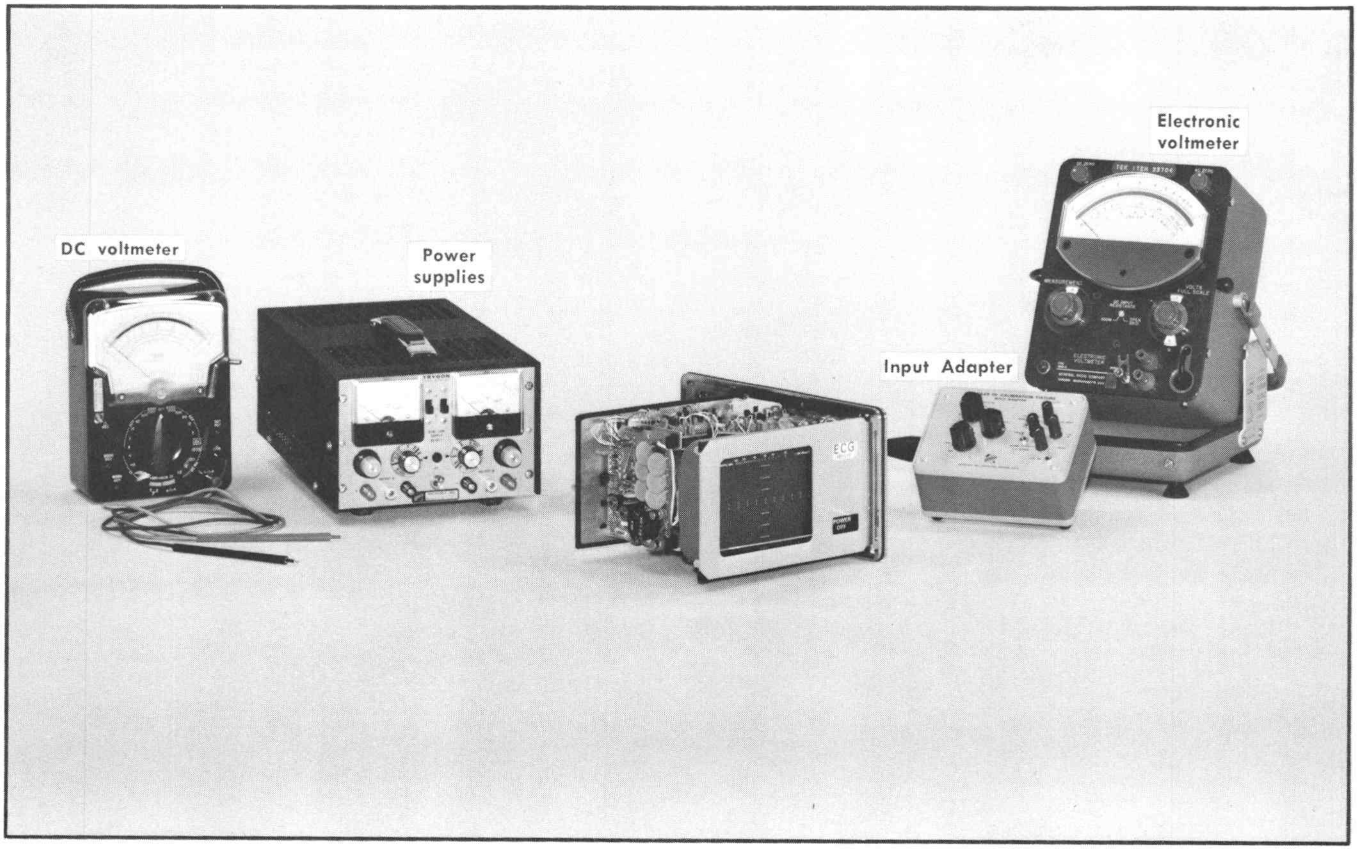


Fig. 6-2. Equipment required for steps 1 through 4.

1. Adjust +17-Volt Supply

a. Test equipment setup is shown in Fig. 6-2 and 6-3.

b. Connect the electronic voltmeter between the +17-volt test point, TP527, and the circuit ground test point, TP595 (Fig. 6-4).

c. ADJUST—R502, +17 Volts (Fig. 6-4), for a meter reading of exactly +17 volts.

2. Check Supply Voltages and Regulation

a. Decrease the Power Supply outputs to + and — 6.0 volts.

b. CHECK—Change in +17-volt supply is less than 0.1 volt.

c. Return the Power Supply outputs to + and —6.7 volts.

d. Connect the electronic voltmeter between circuit ground and each of the supplies given in Table 6-1, and check each supply voltage. Test point locations are shown in Fig. 6-4.

e. Disconnect the electronic voltmeter.

f. Connect the DC Voltmeter to the +3650 supply.

g. CHECK—Meter reading of +3375 V to +3730 V. (This allows for meter load of 20,000 Ω/V on the 4000 V scale.)

h. Disconnect the DC Voltmeter.

TABLE 6-1

Supply	Upper Limit	Lower Limit
—11.7	—12.58	—10.82
—50	52.5	—47.5
+175	+189	+164.5

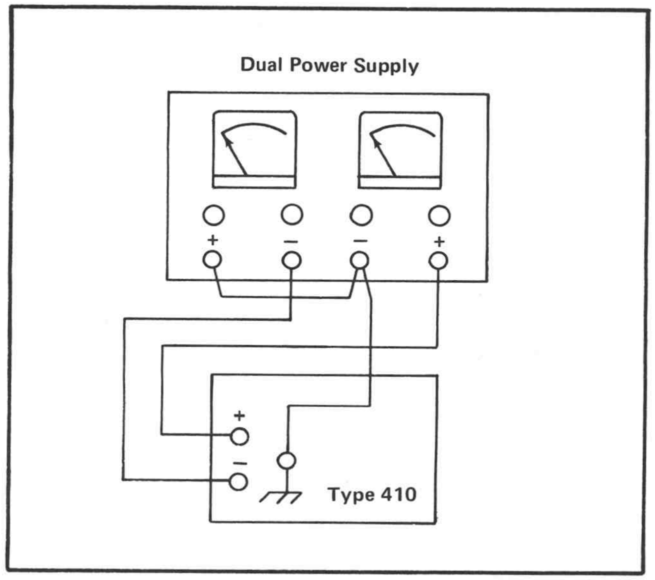


Fig. 6-3. Connections to the Dual Power Supply.

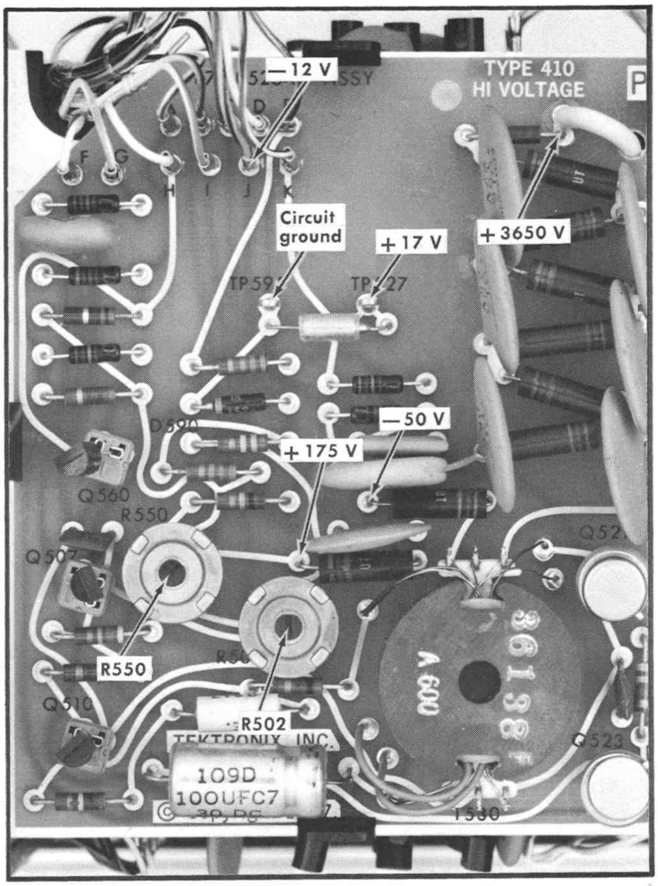


Fig. 6-4. Location of power supply test points, R502, +17 Volts adjustment, and R550, Focus adjustment.

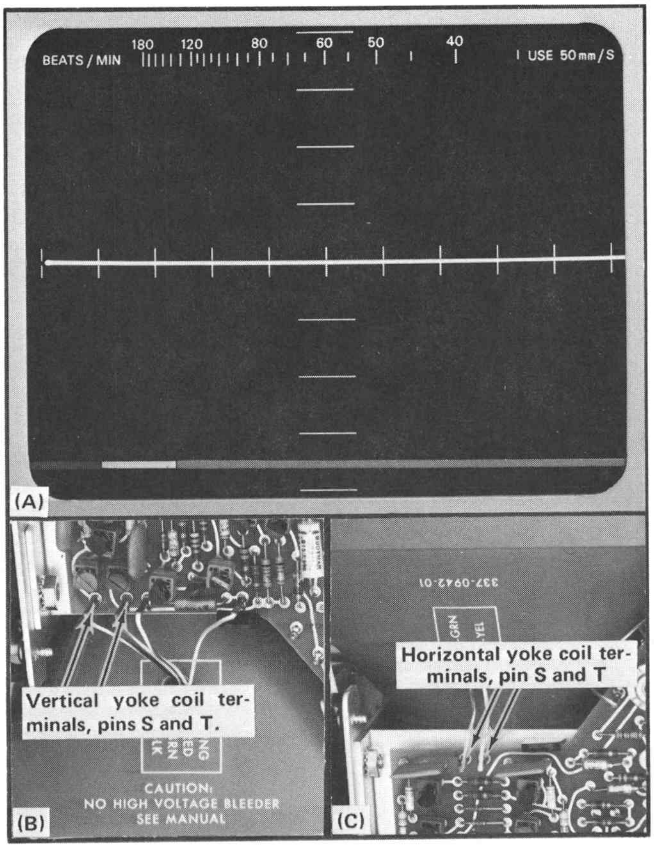


Fig. 6-5. (A) Typical CRT display showing correct alignment of horizontal yoke; (B) Location of vertical yoke terminals S and T, and (C) Location of horizontal yoke terminals S and T.

3. Adjust Focus

a. ADJUST—R550, Focus (Fig. 6-4), for a well-defined trace.

4. Check Yoke Alignment and Magnetic Centering

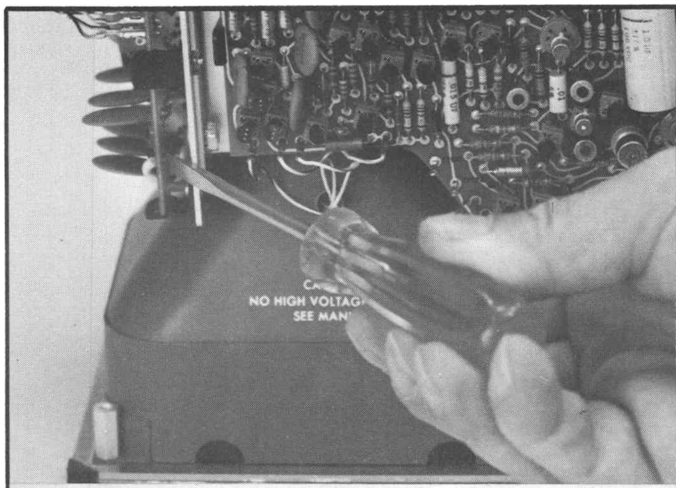
a. Position the trace to graticule center.

b. CHECK—Trace is horizontally aligned within the graticule marks. See Fig. 6-5A. For yoke alignment, follow the procedure given in Fig. 6-6.

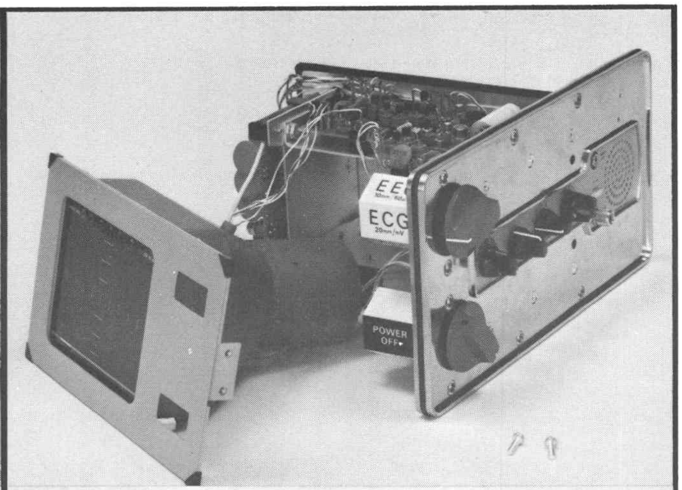
c. Disconnect the yoke coil leads from pins S and T on both the Vertical Amp. Circuit board (Fig. 6-5B) and the Horizontal and Audio circuit board (Fig. 6-5C). Turn the SWEEP SPEED selector to POWER OFF while disconnecting the leads, then to 50 mm/s to make the check.

d. CHECK—Spot is within 2 mm of graticule center. If magnetic centering is necessary, follow the procedure given in Fig. 6-6.

e. Turn the SWEEP SPEED selector to POWER OFF and reconnect the yoke coil leads disconnected in step 4c.



(A) Discharging the High Voltage.



(B) Gaining access to rear of CRT.

1. Set the SWEEP SPEED selector to POWER OFF and discharge the High Voltage caps.

2. Remove the two screws between the SWEEP SPEED and INPUT SELECTOR knobs.

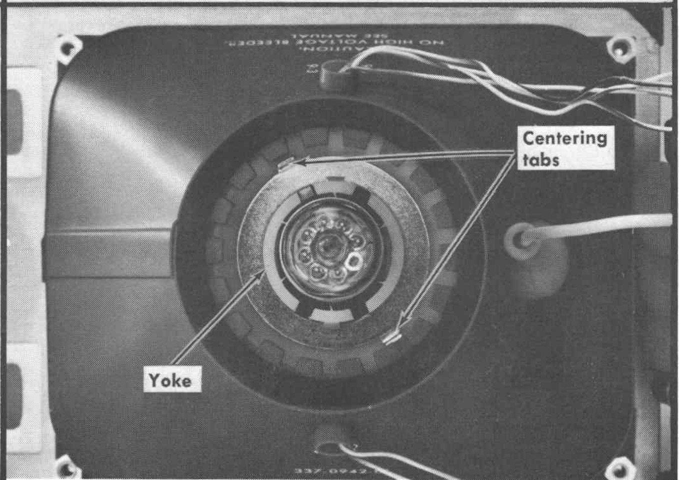
3. Move the CRT shield and front panel out to gain access to the rear of the CRT.

4. Set the SWEEP SPEED selector to 50 mm/s.

5. Rotate the yoke to horizontally align the trace. Use yoke alignment tool, Tektronix part no. 003-0600-00.

6. Set SWEEP SPEED to POWER OFF. Disconnect yoke leads at circuit board. SWEEP SPEED to 50 mm/s. Adjust two centering magnets to place spot at graticule center.

7. Set SWEEP SPEED to POWER OFF, discharge high voltage caps. Reconnect yoke leads. Re-install CRT shield assembly.



(C) Location of yoke and centering magnets.

Fig. 6-6. Aligning the yoke and centering magnets.

NOTES

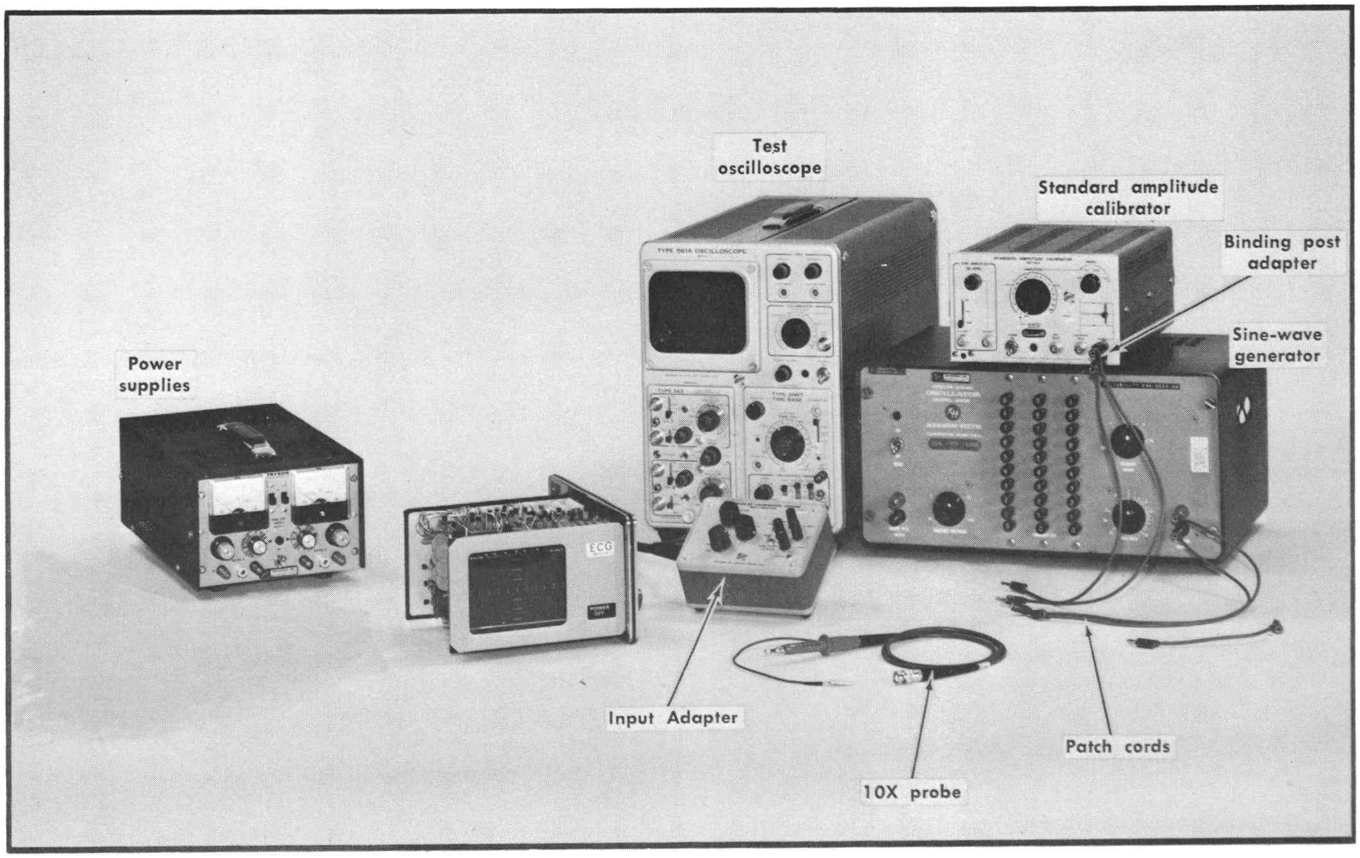


Fig. 6-7. Equipment required for steps 5 through 20.

VERTICAL AMPLIFIER

Control Settings

Type 410

INPUT SELECTOR	ECG
SWEEP SPEED	50 mm/s
VERTICAL SIZE	CCW
VERTICAL POSITION	Midrange
ECG LEAD SELECTOR	I
LOUDNESS	CCW

Input Adapter

+(ATTEN)	×10,000
—(ATTEN)	×10,000
CM ON	OFF
MODE	BAL
INPUT SELECTOR	ECG
ECG LEAD SELECTOR	I

Test Oscilloscope

Vertical (Channel 1)	
(+)Input Coupling	DC
(—)Input Coupling	GND
Mode	Ch 1
Trigger	Ch 1
Volts/Division	0.5 Volts
Horizontal	
Triggering Level	Free Run
Slope	+
Coupling	AC Slow
Source	Int
Mode	Normal
Time/Division	1 ms
Indicator	
Focus	Well-defined trace
Intensity	Nominal brightness
Power	ON

5. Adjust Q119 Collector Voltage

a. Test equipment setup is shown in Fig. 6-7.

b. Position the test oscilloscope free running trace exactly two divisions below the horizontal graticule centerline.

c. Connect the 10× probe from TP120 (Fig. 6-8) on the Vertical Amp. board to the test oscilloscope Ch 1 (+) input connector.

d. ADJUST—R212, Collector Volts (Fig. 6-8A) so that the test oscilloscope trace is positioned exactly 0.2 divisions below the graticule centerline (Fig. 6-8B). This indicates a Q119 collector voltage level of +9.0 volts (1.8 div × 5 V/div = 9 V).

e. Remove the 10× probe from TP120.

6. Adjust Vertical Size Balance

a. ADJUST—R139, Vert Size (Fig. 6-8A), for minimum trace shift while rotating the VERTICAL SIZE control throughout its range. The allowable trace shift is ≤2 mm.

7. Adjust Vertical Gain

a. Connect the standard amplitude calibrator output to the Input Adapter (+) INPUT, using a binding post adapter ground terminal and the Input Adapter ground terminal.

b. Set the standard amplitude calibrator for a 20-volt +DC mixed output.

c. Set the VERTICAL SIZE control to its detent (CAL) position.

d. ADJUST—R124, Gain (Fig. 6-8A), for exactly 4 centimeters of vertical display. See Fig. 6-9B.

8. Check Calibrated Deflection Sensitivity

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG.

b. Set the standard amplitude calibrator for a 2-volt +DC mixed output.

c. CHECK—4 centimeters, ±0.2 cm, of vertical display.

d. Set the Type 410 and Input Adapter INPUT SELECTOR switches to AUX.

e. Set the standard amplitude calibrator for a 100-volt +DC mixed output.

f. CHECK—2 centimeters, ±0.1 cm, of vertical display.

9. Check Vertical Range

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

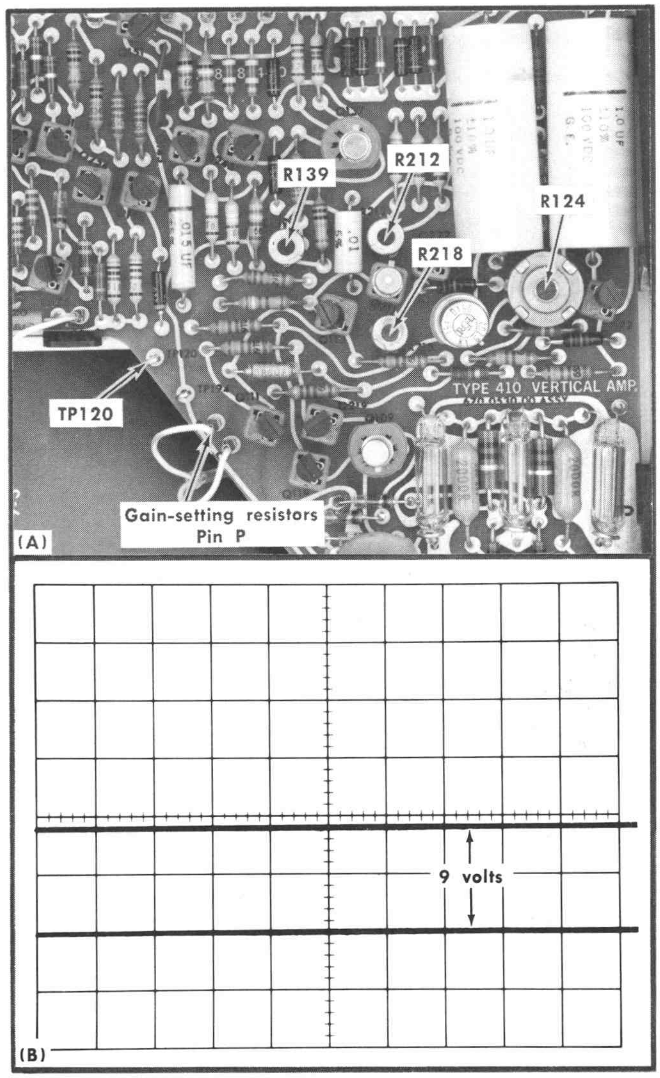


Fig. 6-8. (A) Location of Vertcial Amplifier controls and test points; (B) Typical CRT display showing correct adjustment of R212, Collector Volts.

b. Rotate the VERTICAL SIZE control fully counterclockwise and set the standard amplitude calibrator for a 20-volt +DC mixed output.

c. CHECK—≤1.3 centimeters of vertical display (Fig. 6-9C).

d. Rotate the VERTICAL SIZE control fully clockwise and set the standard amplitude calibrator for a 10-volt +DC mixed output.

e. CHECK— ≥6 centimeters of vertical display (Fig. 6-9A).

NOTE

If the VERTICAL SIZE control has the correct range, as specified in steps 9c and e, proceed to step 11. Failure to meet these specifications requires that step 10 be performed.

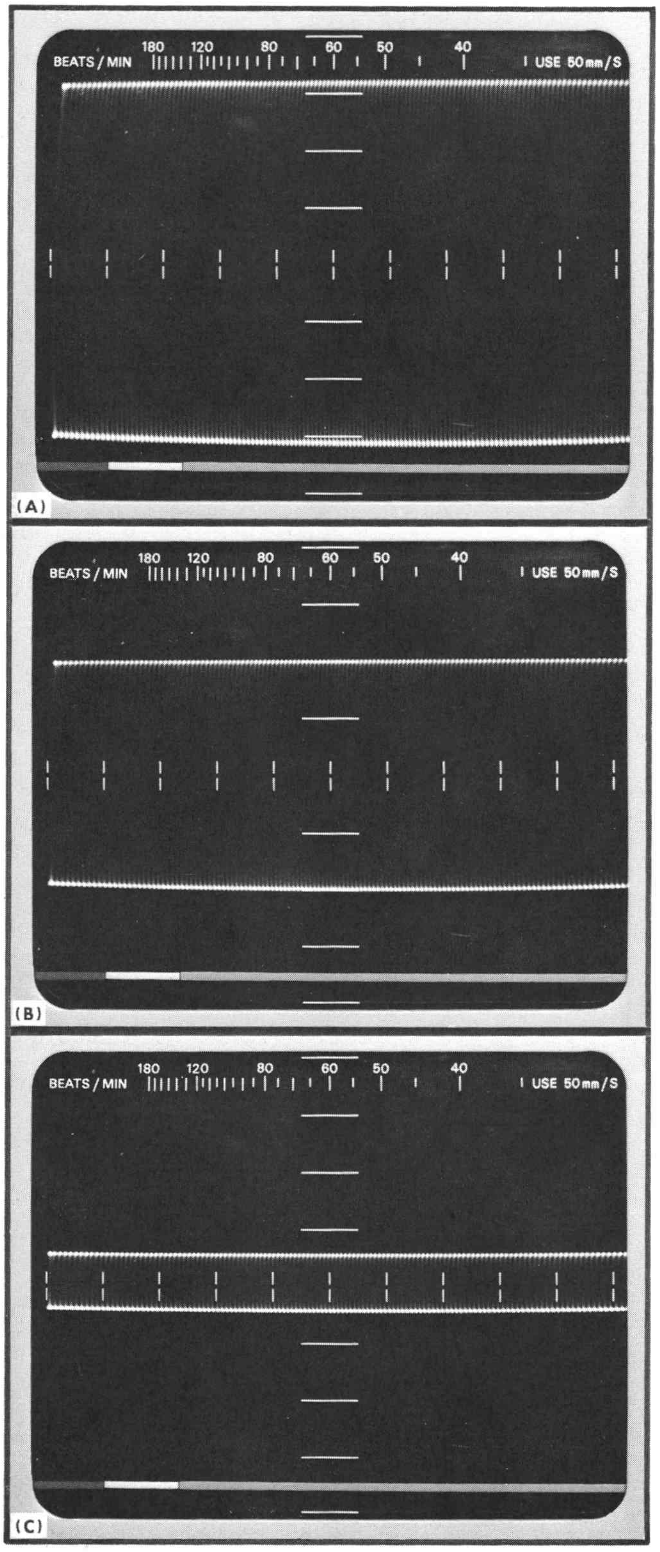


Fig. 6-9. Typical CRT displays showing correct adjustment of R124, Gain, with the VERTICAL SIZE control (A) fully clockwise, (B) in CAL detent, and (C) fully counterclockwise.

10. Adjust Vertical Size Knob

a. If the VERTICAL SIZE control clockwise specification is within tolerance ($\geq$6 cm), proceed to step 10e.

b. Rotate the VERTICAL SIZE control fully clockwise and set the standard amplitude calibrator for a 10-volt +DC mixed output.

c. ADJUST—R124, Gain (Fig. 6-8A), for slightly more than 6 centimeters of vertical display.

d. Set the standard amplitude calibrator for a 20-volt +DC mixed output and proceed to step 10g.

e. Set the VERTICAL SIZE control fully counterclockwise and set the standard amplitude calibrator for a 20-volt +DC mixed output.

f. ADJUST—R124, Gain (Fig. 6-8A), for slightly less than 1.3 centimeters of vertical display.

g. Set the VERTICAL SIZE control to its detent (CAL) position and remove the knob by loosening the set screw.

h. ADJUST—VERTICAL SIZE control (by turning the shaft only) for exactly 4 centimeters of vertical display.

i. Replace the knob and tighten the set screw.

j. Recheck the calibrated deflection sensitivity and vertical size range, steps 8 and 9.

11. Check Amplifier Noise

a. Remove the standard amplitude calibrator signal from the Input Adapter.

b. Connect a short patch cord between the Input Adapter (+) and (—) INPUTS.

c. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG.

d. Set the VERTICAL SIZE control to its detent (CAL) position.

e. CHECK—Peak-to-peak noise does not exceed 0.1 cm of vertical display (subtract normal trace width).

f. Remove the patch cord from the Input Adapter (+) and (—) INPUTS.

12. Adjust Common Mode Rejection Balance

a. Set the test oscilloscope Time/Division switch to 10 ms.

b. Connect the sine-wave generator output to the Input Adapter C.M. IN connector with a patch cord. Connect a patch cord between the ground terminals of the Input Adapter and the sine-wave generator.

c. Connect a 10× probe across the sine-wave generator output and connect to the test oscilloscope (+) input connector.

d. Set the sine-wave generator for a test oscilloscope display of 1 division (5 volts peak to peak) at 60 hertz. Adjust the Triggering Level for a stable display.

e. Place the Input Adapter C.M. ON switch to its ON (left) position.

f. ADJUST—R218, Com Mode Bal (Fig. 6-10A) for minimum display on the Type 410 CRT. See Fig. 6-10B.

13. Check Common Mode Dynamic Range

a. While viewing the Type 410 display, slowly increase the sine-wave generator signal amplitude until the display begins to increase rapidly.

b. CHECK—Teks oscilloscope display amplitude is ≥1.2 divisions (≥6 volts peak to peak). This indicates a common mode dynamic range of ≥ + and − 3 volts.

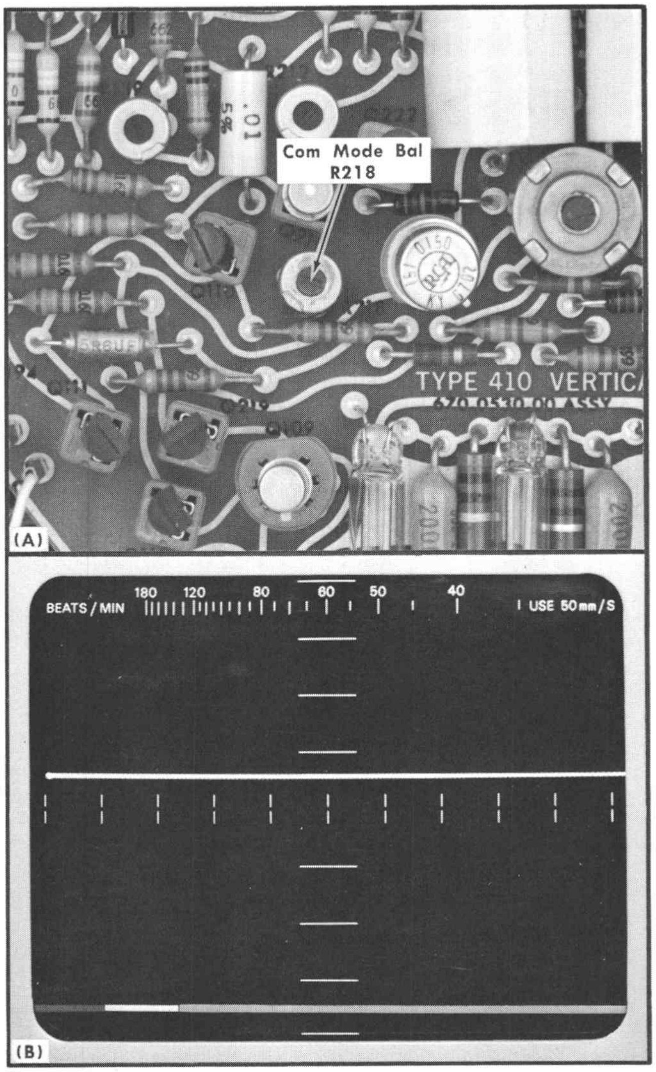


Fig. 6-10. (A) Location of R218 Com Mode Bal; (B) Typical CRT display showing R218 properly adjusted.

c. Reset the sine-wave generator for a test oscilloscope division of 1 division (5 volts peak to peak) at 60 hertz.

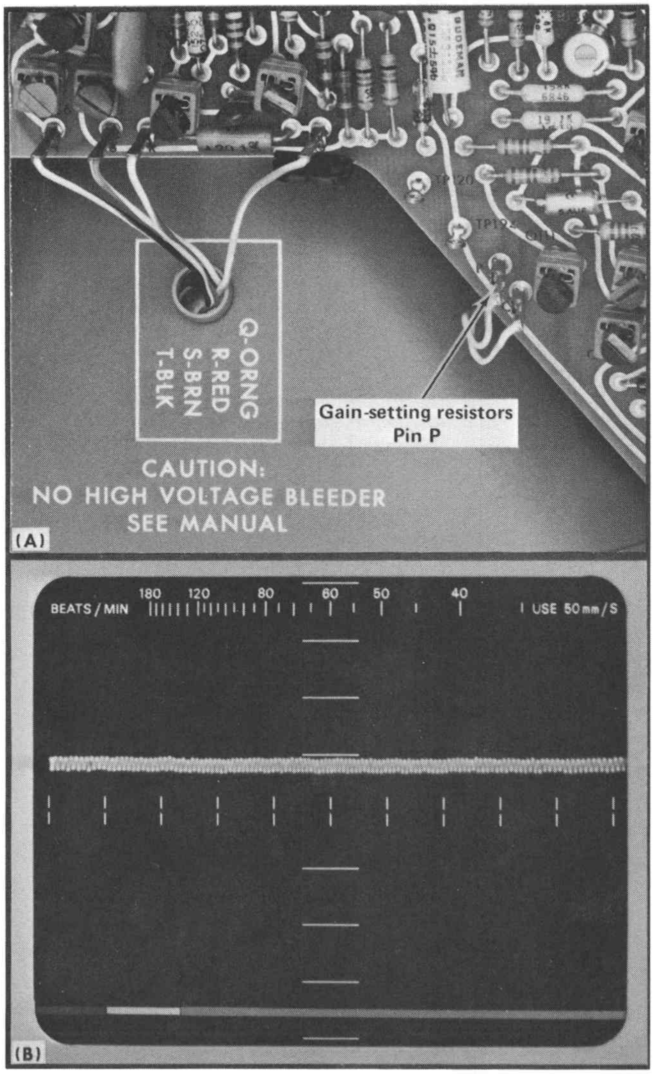


Fig. 6-11. (A) Location of pin P (gain-setting resistors); (B) Typical CRT display when checking CMRR.

14. Check Common Mode Rejection Ratio (0 Ω Source Impedance Unbalance)

a. Remove the gain-setting resistors by disconnecting the lead from pin P (Fig. 6-11A) on the Vertical Amp. circuit board.

b. Rotate the VERTICAL SIZE control to its detent (CAL) position. (The Type 410 and Input Adapter INPUT SELECTOR switches should be in EEG.)

c. CHECK—Type 410 display amplitude is ≤2 mm (CMRR of ≥500,000:1, or ≤10 μV of a 5-volt signal). Fig. 6-11B.

d. Check the CMRR with the Type 410 and Input Adapter INPUT SELECTOR switches ECG and AUX. Required common mode rejection ratio is ≥500,000:1.

15. Check Common Mode Rejection Ratio (5 kΩ Source Impedance Unbalance)

a. Switch the Input Adapter Mode to + Unbal.

b. CHECK—Type 410 display amplitude should not exceed .67 cm (CMRR of $\geq$150,000:1).

c. CHECK—CMRR with the Type 410 and Input Adapter Selector switches in ECG and EEG. Common-Mode Rejection should be $\geq$150,000:1.

d. Switch the Input Adapter Mode to —Unbal and repeat steps b and c.

16. Check Common Mode Rejection Ratio With 100 mV DC Offset

a. With the sine-wave generator connected as in steps 12 through 14, connect the standard amplitude calibrator output to the Input Adapter (—) INPUT, using a binding post adapter and a patch cord. Connect a patch cord between the ground terminals of the binding post adapter and the Input Adapter.

b. Set the Input Adapter (—) ATTEN switch to X1000.

c. Set the standard amplitude calibrator for a 100-volt +DC output (not mixed).

d. CHECK—Type 410 display amplitude is $\leq$0.67 centimeter (indicates a CMRR of at least 150,000:1 with +100 mV DC offset).

e. Repeat the check with the Type 410 Input Adapter INPUT SELECTOR switches in ECG and AUX.

f. Set the standard amplitude calibrator for a 100-volt —DC output.

g. CHECK—Type 410 display amplitude is $\leq$0.67 centimeter (indicates a CMRR at least 150,000:1 with —100 mV DC offset).

h. Repeat the check with the Type 410 and Input Adapter INPUT SELECTOR switches set to ECG and EEG.

i. Reconnect the gain-setting resistors by reconnecting the lead to Pin P on the Vertical Amp circuit board.

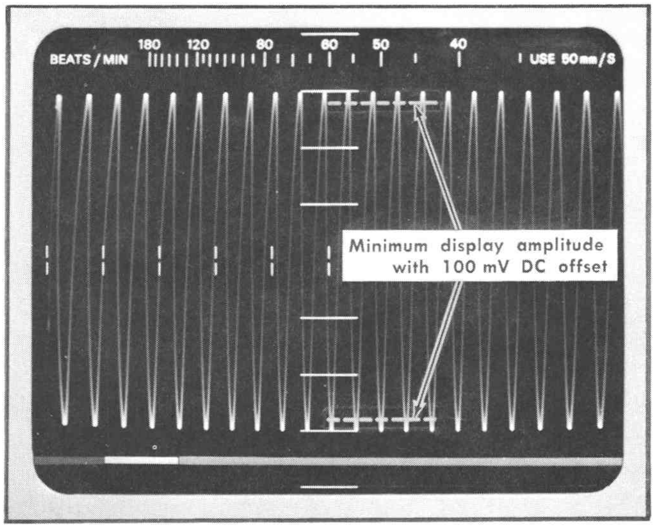


Fig. 6-12. Typical CRT display when checking gain with 100 mV DC offset.

17. Check Gain With 100 mV DC Offset

a. Move the sine-wave generator signal from the Input Adapter C.M. IN connector to the (+) INPUT connector.

b. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

c. Set the standard amplitude calibrator for a zero-volt output and adjust the sine-wave generator for a 6-centimeter display at 10 hertz (see Fig. 6-12).

d. Set the standard amplitude calibrator for a 100-volt +DC output.

e. CHECK— $\geq$5.7 centimeters of vertical display (see Fig. 6-12).

f. Set the standard amplitude calibrator for a 100-volt —DC output.

g. CHECK— $\geq$5.7 centimeters of vertical display.

18. Check Overdrive Recovery Time

a. Set the Type 410 and Input Adapter INPUT SELECTOR switches to EEG. Set the Type 410 SWEEP SPEED to 50 mm/s.

b. Adjust the sine-wave generator for a 2-centimeter display at 60 hertz (see Fig. 6-13).

c. Switch the standard amplitude calibrator from —DC to +DC.

d. CHECK—Time required for return of usable display must be less than 4 seconds.

e. Switch the standard amplitude calibrator from +DC to —DC.

f. CHECK—Time required for return of usable display must be less than 4 seconds.

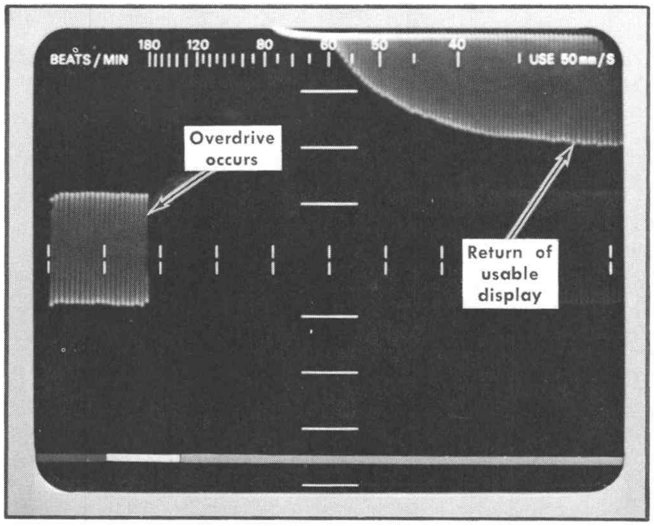


Fig. 6-13. Typical CRT display when checking overdrive recovery time.

19. Check Bandwidth High Frequency —3 dB Point

a. Set the SWEEP SPEED selector to 25 mm/s.

b. Adjust the sine-wave generator for a 6-centimeter display at 20 hertz.

c. With the display centered, slowly increase the sine-wave frequency until the display amplitude decreases to 4.2 centimeters. See Fig. 6-14.

d. CHECK—Frequency at —3 dB is 85 to 115 Hz for EEG.

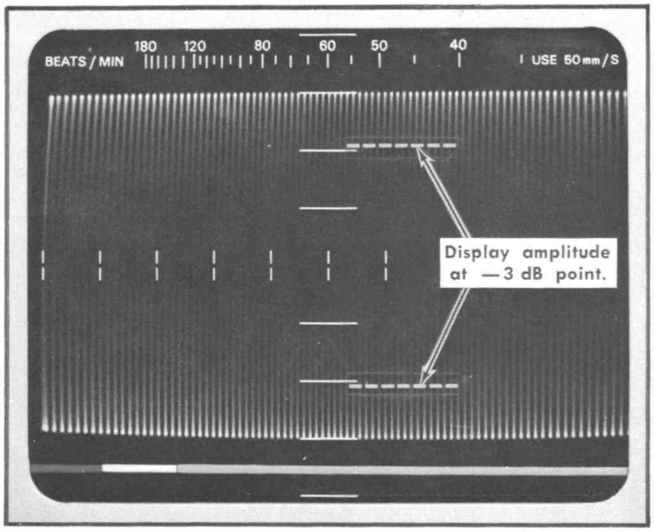


Fig. 6-14. Typical CRT display when checking high frequency—3 dB point.

e. Repeat steps b and c with the Type 410 and Input Adapter INPUT SELECTOR switches in ECG and AUX. (It may be necessary to place the Input Adapter (+) ATTEN switch to X100 when checking AUX, then return to X10,000.)

f. CHECK—Frequency at —3 dB is 212.5 to 287.5 Hz for ECG and AUX.

g. Disconnect the sine-wave generator, leaving only the standard amplitude calibrator connected.

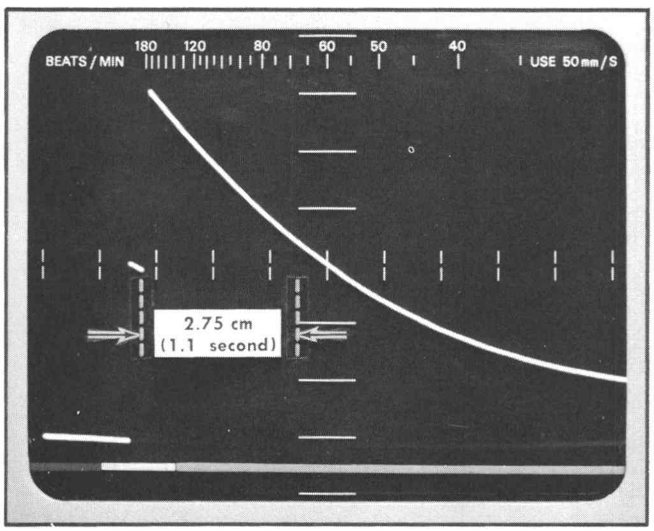


Fig. 6-15. Typical CRT display when checking low frequency—3 dB point.

20. Check Bandwidth Low Frequency —3 dB Point

a. Set the Type 410 and Input Adapter INPUT SELECTOR SWITCHES to ECG.

b. Rotate the VERTICAL SIZE control fully clockwise.

c. Move the standard amplitude calibrator signal from the Input Adapter (—) INPUT connector to the (+) INPUT connector.

d. Set the standard amplitude calibrator for a 5-volt —DC output and position the trace to the third cm mark below graticule center (see Fig. 6-15).

e. Switch the standard amplitude calibrator from —DC to +DC.

f. CHECK—Trace must step to at least the third cm mark above graticule center and decay to graticule center in more than 1.1 seconds (see Fig. 6-15).

g. Disconnect all test equipment.

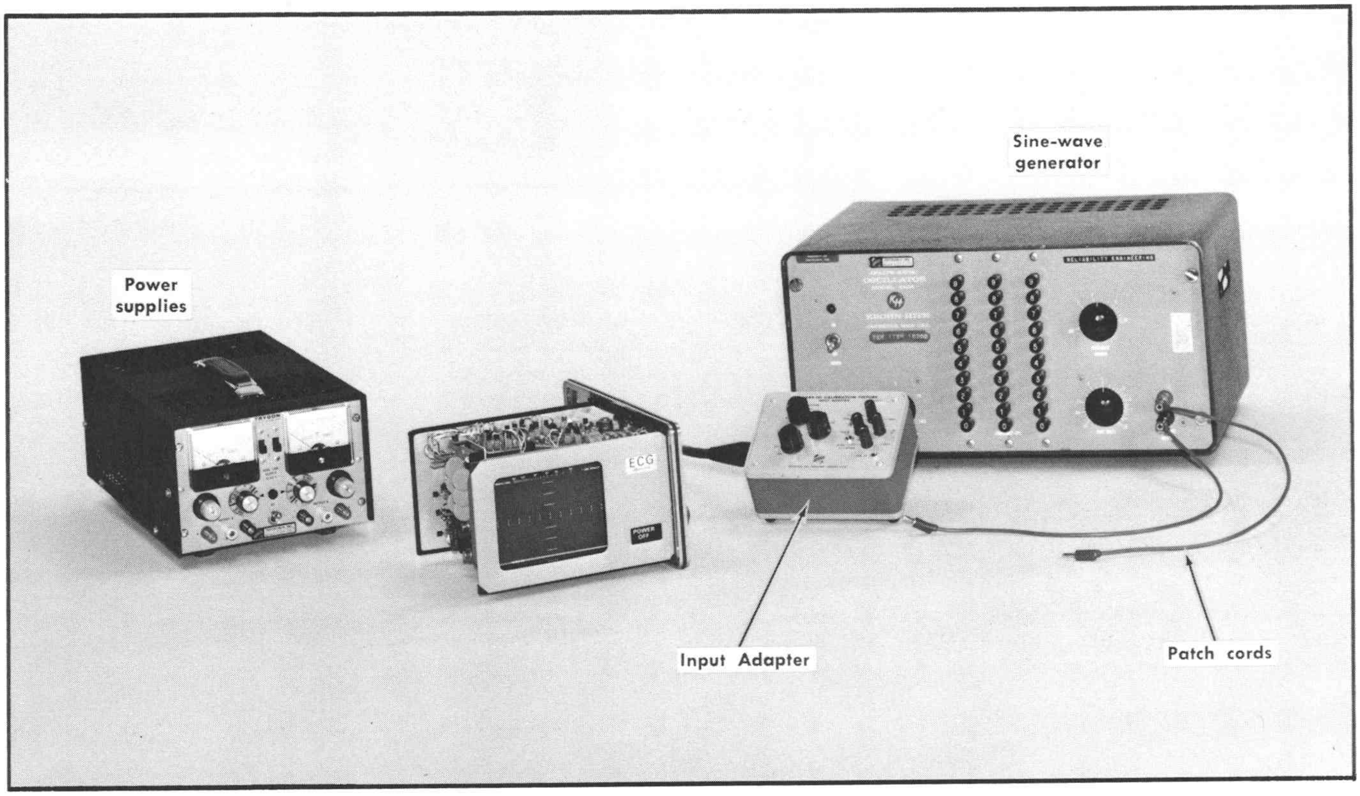


Fig. 6-16. Equipment required for steps 21 and 22.

TRIGGERING

Control Settings

Type 410

INPUT SELECTOR	ECG
SWEEP SPEED	50 mm/s
VERTICAL SIZE	CAL
VERTICAL POSITION	Midrange
ECG LEAD SELECTOR	I
LOUDNESS	CCW

Input Adapter

+ (ATTEN)	×100
— (ATTEN)	×10,000
CM ON	OFF
MODE	BAL
INPUT SELECTOR	ECG
ECG LEAD SELECTOR	I

Ⓑ

21. Check Triggering Sensitivity (Slow Rise Signal)

a. Test equipment setup is shown in Fig. 6-16.

b. Connect the sine-wave generator to the (—) Input of the Type 410 Input Adapter with a patch cord.

c. Set the sine-wave generator frequency to 1 Hz, then adjust its output for 0.5 volts peak-to-peak signal, using the test oscilloscope to monitor the output.

d. Rotate the loudness control clockwise until audio tones are heard. There should be one tone for each switching cycle of the trigger circuit. Triggering on both positive and negative slopes of the sine-wave signal is normal.

e. Slowly decrease the Input Signal until triggering is lost. This is indicated by 6 to 10 audible notes per second followed by a free-running sweep.

f. CHECK—Loss of triggering (indicated by increase in audio tone rate) should occur when trigger signal amplitude decreases below 0.5 cm.

22. Check Triggering Sensitivity (Fast Rise Signal)

a. Insert the sine-wave generator output into the Trig Input jack on the Type 410 Input Adapter.

b. Set the sine-wave generator output for 5 volts peak-to-peak signal amplitude at 1 Hz.

c. Switch trigger test On at Type 410 Input Adapter.

d. There should be one audible tone for each cycle appearing on the Type 410 CRT.

e. Slowly decrease input signal amplitude until audible tone **rate** changes.

f. CHECK—Tone rate should increase when trigger signal amplitude decreases below 0.7 cm on the Type 410 CRT.

g. Rotate "LOUDNESS" control CCW and disconnect all test equipment.

NOTES

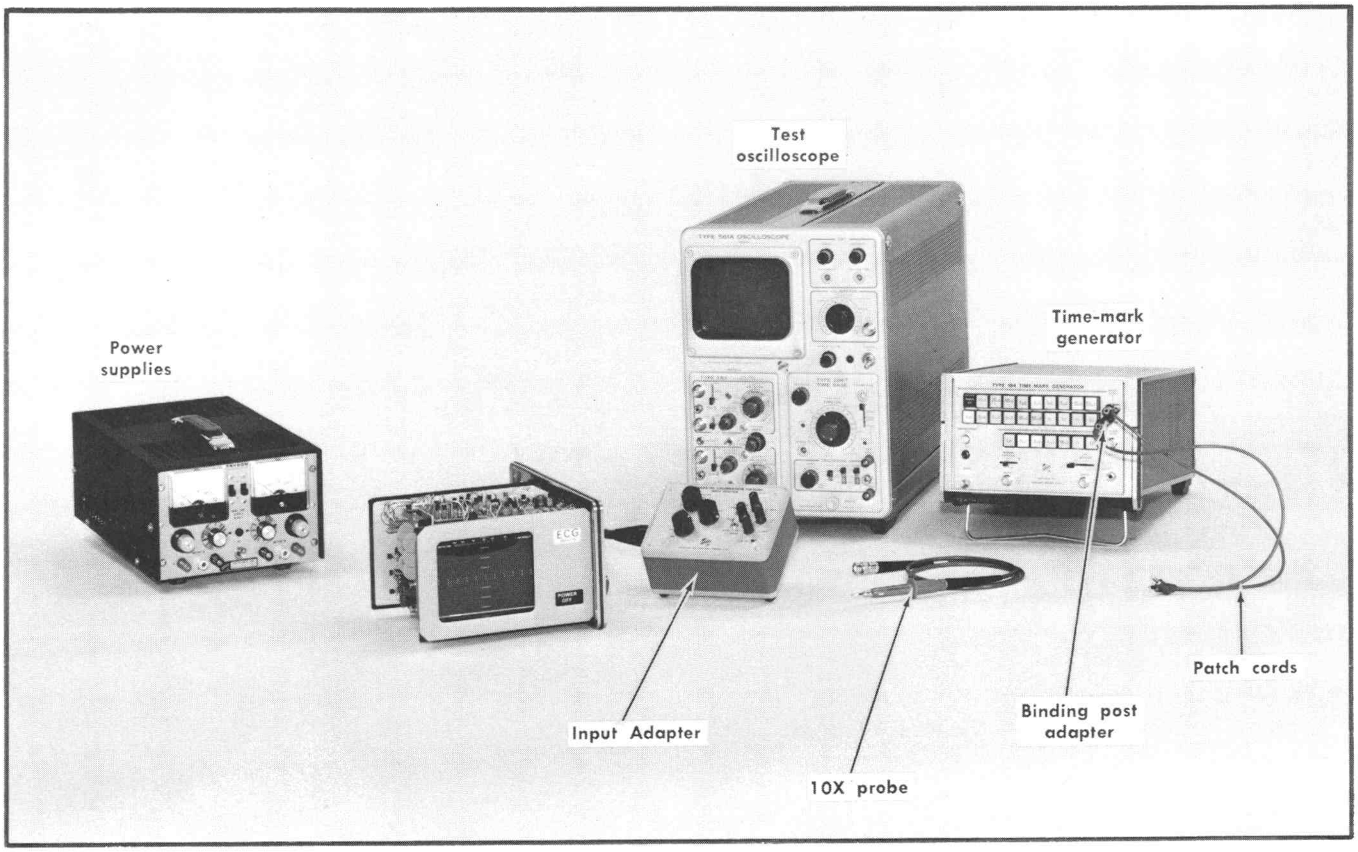


Fig. 6-17. Equipment required for steps 23 through 28.

HORIZONTAL CIRCUITS

Control Settings

Type 410

INPUT SELECTOR	**EEG**
SWEEP SPEED	50 mm/s
VERTICAL SIZE	CCW
VERTICAL POSITION	Midrange
ECG LEAD SELECTOR	I
LOUDNESS	CCW

Input Adapter

+ (ATTEN)	**×10,000**
— (ATTEN)	×10,000
CM ON	OFF
MODE	BAL
INPUT SELECTOR	**EEG**
ECG LEAD SELECTOR	I

Test Oscilloscope

Vertical (Channel 1)

(+) Input Coupling	DC
(—) Input Coupling	GND
Mode	Ch 1
Trigger	Ch 1
Volts/division	0.2 Volts

Horizontal

Triggering Level	Free Run
Slope	+
Coupling	AC Slow
Source	Int
Mode	Normal
Time/Division	20 ms

Indicator

Focus	Well-defined trace
Intensity	Normal brightness
Power	On

23. Check Trigger Gate

a. Test equipment setup is shown in Fig. 6-17.

b. Connect a 10× probe from pin G (Q339 emitter) on the Horiz. and Audio circuit board (Fig. 6-18A) to the test oscilloscope Ch 1 (+) vertical input.

c. Adjust the test oscilloscope Triggering Level control for a stable display.

d. CHECK—Time for 1 complete cycle is between 100 ms and 166 ms; gate width is between 94 ms and 156 ms. See Fig. 6-18B. Gate amplitude is +5 to +7.5 volts.

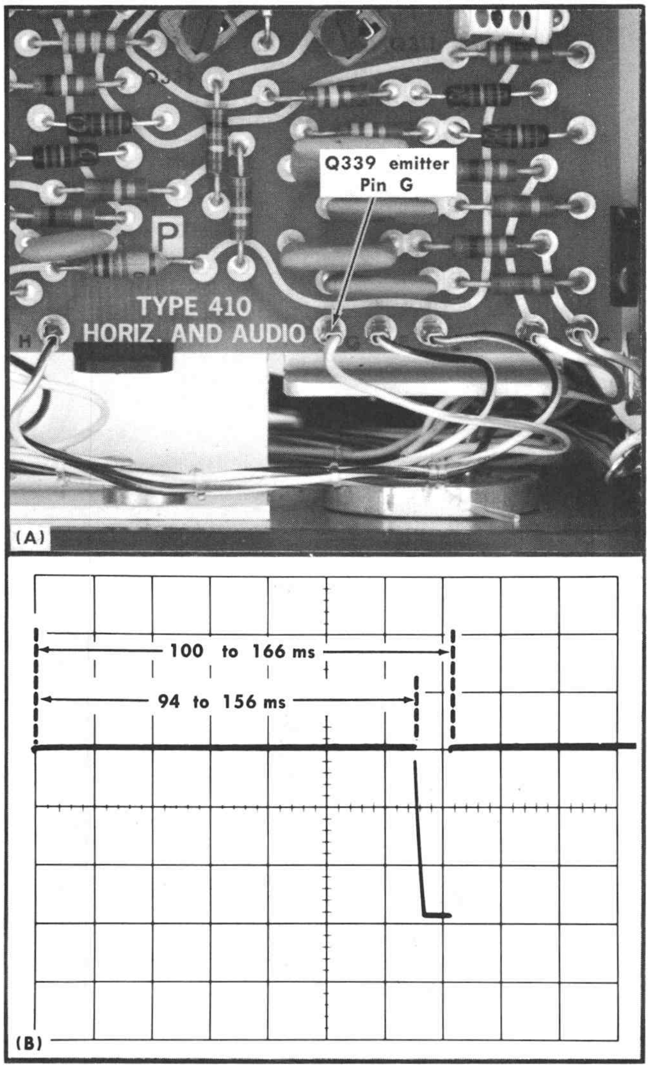


Fig. 6-18. (A) Location of pin G (Q339 emitter); (B) Typical CRT display when checking trigger gate.

24. Check Sweep Free Run Delay

a. Connect the time-mark generator marker output to the Input Adapter (+) INPUT using a binding post adapter and a patch cord. Connect a patch cord between the binding post adapter ground terminal and the Input Adapter ground terminal. Set VERTICAL SIZE control fully clockwise.

b. Set the time-mark generator for 0.5-second markers.

c. Set the Type 410 and Input Adapter INPUT SELECTOR switches to ECG.

d. Adjust the VERTICAL SIZE control for a triggered display on the Type 410.

e. Change the test oscilloscope Time/Division switch to 1 s.

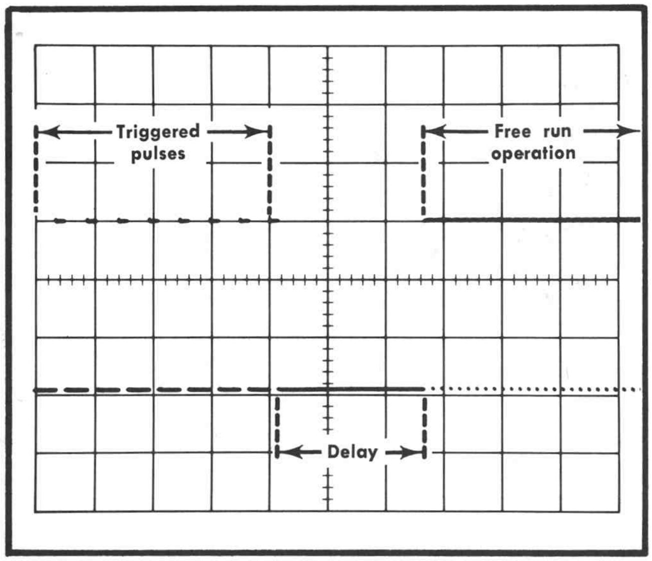


Fig. 6-19. Typical CRT display when checking sweep free run delay.

f. While observing the display on the test oscilloscope, disconnect the time-mark generator signal from the Input Adapter (+) INPUT and note the length of time between the last triggered pulse and the astable operation of the Trigger Multi.

g. CHECK—Sweep free run delay is between 2 and 4 seconds. See Fig. 6-19.

h. Remove the 10X probe.

25. Adjust Battery Check Cal

a. Change the SWEEP SPEED selector to BATTERY CHECK.

b. Set the test power supply + output to +5.95 volts.

c. With the VERTICAL POSITION control, move the spot to a point near the colored scale in the lower screen area.

d. ADJUST—R397, Battery Check Cal (Fig. 6-20A), to horizontally position the spot to the juncture of the red and yellow zones on the scale. See Fig. 6-20B.

26. Adjust Horizontal Position and Sweep Length

a. Adjust the test power supply for +6.1 volts ±0.5% and —6.1 volts ±2%.

b. Set the SWEEP SPEED selector to 50 mm/s and vertically center the trace with the VERTICAL POSITION control.

c. ADJUST—R392, Horiz Position, and R390, Sweep Width (Fig. 6-21A) so that the trace starts on the first graticule mark and ends on the last graticule mark. See Fig. 6-21B.

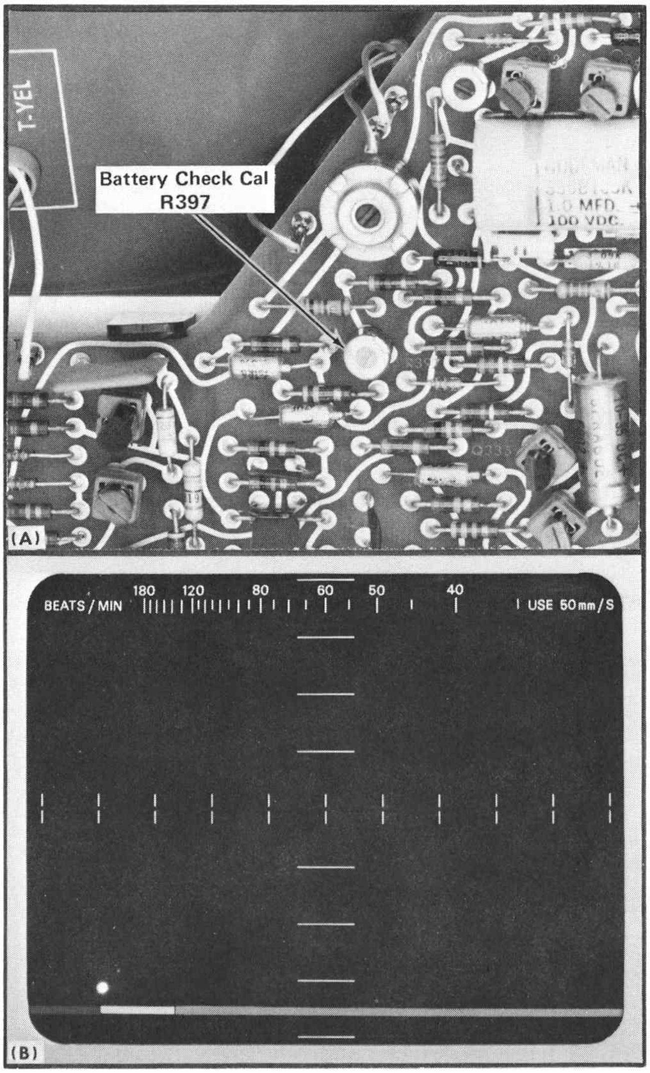


Fig. 6-20. (A) Location of R397, Battery Check Cal; (B) Typical CRT display showing proper adjustment of R397.

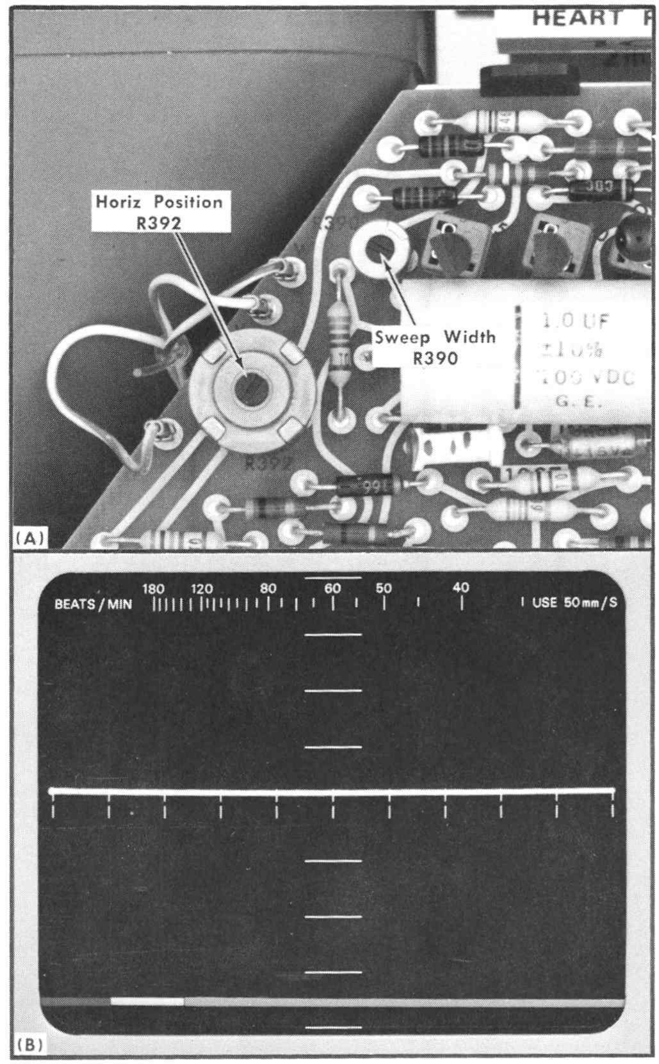


Fig. 6-21. (A) Location of R392, Horiz Position, and R390, Sweep Width; (B) Typical CRT display showing correct adjustment of R390 and R392.

NOTE

Adjustment of R392 and R390 interact and several adjustments may be necessary.

27. Adjust Basic Sweep Timing

a. Set the test power supply + output to +6.7 volts.

b. Connect the time-mark generator marker output to the Input Adapter (+) INPUT and set the time-mark generator for 0.1-second and 0.5-second markers.

c. ADJUST—R375, Timing (Fig. 6-22A), so that the second and fourth 0.5-second markers coincide with the 120 and 40 BEATS/MIN on the Heart Rate Scale. See Fig. 6-22B. (It may be convenient to position the display with the VERTICAL POSITION control. After the adjustment has been made, return the trace to graticule center.)

28. Check Timing Accuracy

a. Set the time-mark generator for 1-second markers.

b. Note the distance between the first and last time markers for each SWEEP SPEED position. Refer to Fig. 6-23.

c. CHECK—Distance noted in step 6 is 10 centimeters, ±0.5 cm, with the SWEEP SPEED selector in the 25, 50, and 100 mm/s positions.

d. Disconnect all test equipment.

This completes the calibration procedure for the Type 410. If the instrument has been completely checked and calibrated to the tolerances given in this procedure, it will meet the electrical characteristics listed in the Performance Requirement column in the Characteristics section of this manual.

29. Battery Pack Calibration

016-0107-02 Models 1, 2, and 3.

CAUTION

Before soldering on the pack anywhere, remove the pack from the Type 410 and disconnect the power cord.

1. Disconnect the 2 wires from the + and — ends of the battery (center wire may remain connected).

2. Check that the 115/230 V switch (S603) is set to the available line voltage range.

3. Check that the two primary taps are properly connected for the available line voltage.

4. Preset R631 and R662 fully counterclockwise.

5. Prepare a variable DC power supply for the following requirements:

   a. Supply must be floating (not connected to ground at any point).

   b. Must cover a range of about 10 to 13 volts.

   c. Must be capable of "sinking" 240 mA. This requirement can be met by shunting the supply with a 35 Ω, 5 W resistor.

   d. Connect a voltmeter across the supply.

6. Connect the floating variable DC supply in place of the battery (same polarity as battery was connected). It is not necessary to use a dual supply.

7. Set the variable DC supply to 11 volts.

8. Connect the Battery Pack to the power line.

9. Turn R662 very slowly clockwise to the point at which the relay click is heard.

10. Slowly increase the variable supply voltage until the relay clicks again. Note that the supply voltage is within approximately 11.5 to 12.0 volts.

11. Connect a milliammeter between TP640 (+ lead), and TP641 (— lead). Adjust R631 for a meter reading of exactly 240 mA.

12. Reduce the variable power supply output voltage to 10 volts and note that the current drops to within 5 to 20 mA.

13. Unplug the line cord and disconnect the variable DC supply and milliammeter.

14. Carefully resolder the wires to the + and — battery terminals.

15. Check for voltage between J641 and J642, and between J642 and J643. If voltage is zero in either case, check fuses F641 and/or F643.

016-0107-02 Models 4 and Up.

CAUTION

Before soldering anywhere on the Pack, remove the Pack from the Type 410 and disconnect the power cord.

1. Disconnect the 2 wires from the + and — ends of the battery (center wire may remain connected).

2. Check that the 115/230 V switch (S603) is set to the available line voltage range.

3. Check that the two primary taps are properly connected for the available line voltage.

4. Preset R631 and R662 fully counterclockwise.

5. Prepare a variable DC power supply for the following requirements:

   a. The supply must float (not connected to ground at any point).

   b. Must cover a range of about 10 to 13 volts.

   c. Must be capable of sinking 240 mA. This requirement can be met by shunting the supply with a 35 Ω, 5 W resistor.

   d. Must have a voltmeter across the supply.

6. Connect the floating variable DC supply in place of the battery (same polarity as battery was connected). It is not necessary to use a dual supply.

7. Set the variable DC supply to 11 volts.

8. Connect the Power Pack to the power line.

9. Turn R662 very slowly clockwise in small increments. Wait for 10 seconds after each increment and again listen for the relay click.

10. Slowly increase the variable supply voltage in small increments. Wait for 10 seconds after each increment and again listen for the relay click. Note that the supply voltage is within approximately 11.5 to 12.0 volts.

11. Connect a milliammeter between TP640 (+ lead) and TP641 (— lead). Adjust R631 for a meter reading of exactly 240 mA.

12. Reduce the variable power supply output voltage to 10 volts and note that the current reduces to within 5 to 20 mA.

13. Unplug the line cord and disconnect the variable DC supply and milliammeter.

14. Carefully resolder the wires to the + and — battery terminals. Momentarily connect the Battery Pack to the power line.

15. Check for voltage between J641 and J642, and between J642 and J643. If voltage is zero in either case, check fuses F641 and/or F643.

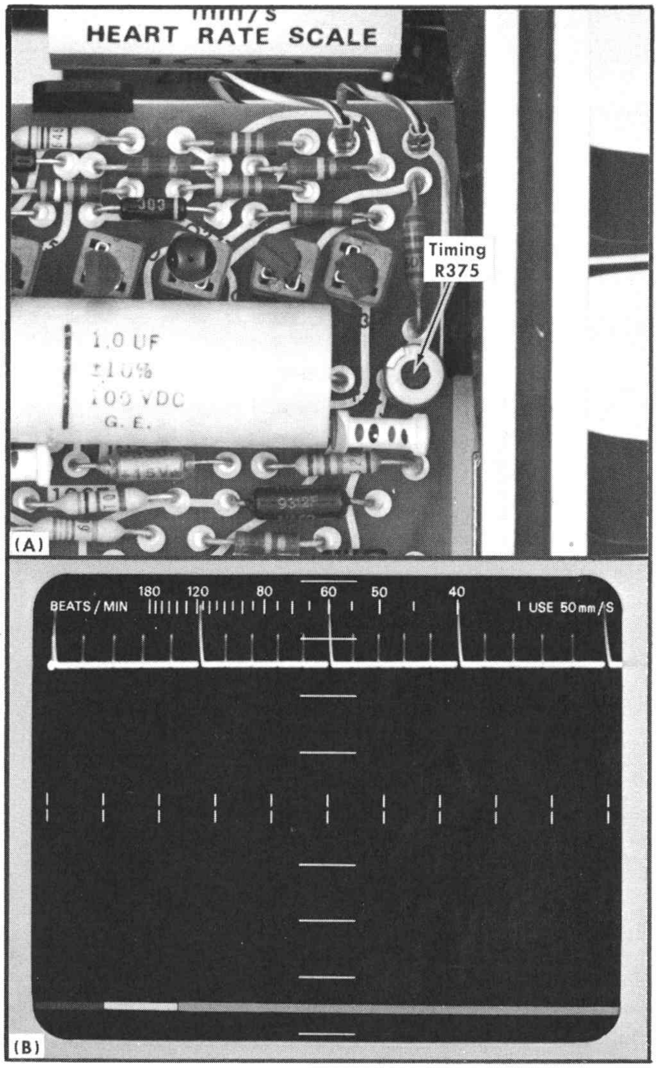


Fig. 6-22. (A) Location of R375, Timing; (B) Typical CRT display showing proper adjustment of R375.

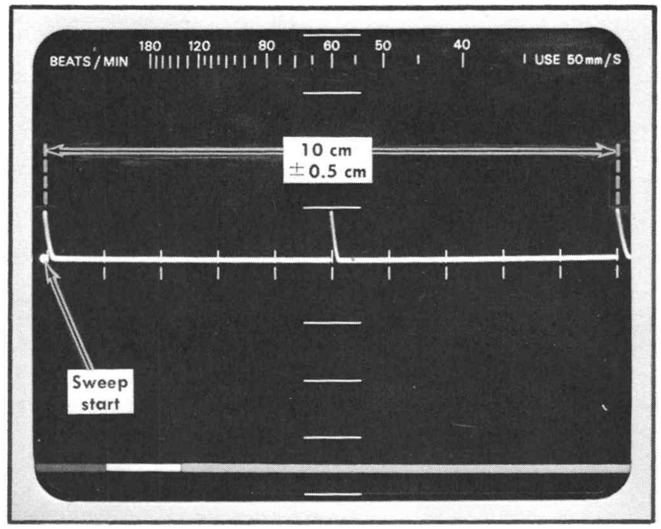


Fig. 6-23. Typical CRT display showing correct timing accuracy.

NOTES

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
◐	Screwdriver adjustment.
▭	Control, adjustment or connector.

SECTION 7
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

Bulbs

B103	150-0067-00	B010100	B109999X	Neon 5AH-B			
B106	150-0067-00			Neon 5AH-B			
B206	150-0067-00			Neon 5AH-B			

Capacitors

Tolerance ±20% unless otherwise indicated.

C102	283-0083-00	XB110000		0.0047 μF	Cer	500 V	5%
C104	290-0247-00	XB110000		5.6 μF	EMT	6 V	10%
C105	283-0010-00	B010100	B109999	0.05 μF	Cer	50 V	
C105	283-0092-00	B110000		0.03 μF	Cer	200 V	+80%—20%
C114	290-0247-00			5.6 μF	Elect.	6 V	10%
C129	285-0598-00			0.01 μF	PTM	100 V	5%
C134	285-0576-00			1 μF	PTM	100 V	10%
C141	285-0719-00			0.015 μF	PTM	100 V	5%
C143	283-0051-00			0.0033 μF	Cer	100 V	5%
C151	283-0051-00			0.0033 μF	Cer	100 V	5%
C180	283-0010-00			0.05 μF	Cer	50 V	
C183	283-0010-00			0.05 μF	Cer	50 V	
C191	290-0261-00			6.8 μF	Elect.	35 V	
C193	290-0134-00			22 μF	Elect.	15 V	
C195	290-0134-00			22 μF	Elect.	15 V	
C234	285-0576-00			1 μF	PTM	100 V	10%
C243	283-0051-00			0.0033 μF	Cer	100 V	5%
C280	283-0010-00			0.05 μF	Cer	50 V	
C283	283-0010-00			0.05 μF	Cer	50 V	
C302	283-0026-00			0.2 μF	Cer	25 V	
C303	283-0059-00			1 μF	Cer	25 V	+80%—20%
C306	283-0026-00			0.2 μF	Cer	25 V	
C307	283-0059-00			1 μF	Cer	25 V	+80%—20%
C311	290-0175-00	B010100	B139999	10 μF	Elect.	35 V	
C311	290-0175-01	B140000		10 μF	Elect.	35 V	
C317	283-0003-00			0.01 μF	Cer	150 V	
C324	290-0269-00			0.22 μF	Elect.	35 V	5%
C326	281-0523-00			100 pF	Cer	350 V	
C328	283-0051-00			0.0033 μF	Cer	100 V	5%
C329	290-0188-00			0.1 μF	Elect.	35 V	10%
C332	290-0188-00			0.1 μF	Elect.	35 V	10%
C333	290-0283-00			0.47 μF	Elect.	35 V	10%
C340	290-0269-00			0.22 μF	Elect.	35 V	5%
C342	283-0051-00			0.0033 μF	Cer	100 V	5%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C343	283-0051-00			0.0033 μF	Cer	100 V	5%
C344	283-0051-00			0.0033 μF	Cer	100 V	5%
C345	281-0524-00			150 pF	Cer	500 V	
C346	283-0001-00			0.005 μF	Cer	500 V	
C355	281-0523-00			100 pF	Cer	350 V	
C356	283-0000-00			0.001 μF	Cer	500 V	
C358	290-0246-00			3.3 μF	Elect.	15 V	10%
C363	281-0580-00			470 pF	Cer	500 V	10%
C366	290-0269-00			0.22 μF	Elect.	35 V	5%
C369	285-0576-00			1 μF	PTM	100 V	10%
C410	283-0010-00			0.05 μF	Cer	50 V	
C440	283-0010-00			0.05 μF	Cer	50 V	
C492	290-0261-00			6.8 μF	Elect.	35 V	
C494	290-0134-00			22 μF	Elect.	15 V	
C496	283-0002-00	B010100	B099999X	0.01 μF	Cer	500 V	
C498	290-0134-00			22 μF	Elect.	15 V	
C505	283-0051-00			0.0033 μF	Cer	100 V	5%
C510	285-0699-00			0.0047 μF	PTM	100 V	10%
C522	283-0067-00			0.001 μF	Cer	200 V	10%
C527	283-0059-00			1 μF	Cer	25 V	+80%—20%
C528	290-0267-00			1 μF	Elect.	35 V	
C530	283-0105-00			0.01 μF	Cer	2000 V	
C531	283-0105-00			0.01 μF	Cer	2000 V	
C532	283-0105-00			0.01 μF	Cer	2000 V	
C533	283-0105-00			0.01 μF	Cer	2000 V	
C534	283-0105-00			0.01 μF	Cer	2000 V	
C535	283-0105-00			0.01 μF	Cer	2000 V	
C540	283-0006-00			0.02 μF	Cer	500 V	
C546	283-0006-00			0.02 μF	Cer	500 V	
C566	283-0024-00			0.1 μF	Cer	30 V	
C597	290-0137-00			100 μF	Elect.	30 V	+75%—15%

Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
D101	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D102	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D103	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D104	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D105	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D106	152-0333-00	XB110000		Silicon	High Speed and Conductance	
D107	*152-0328-00			Silicon	FET Tek Spec	
D108	*152-0328-00			Silicon	FET Tek Spec	
D123	*152-0185-00			Silicon	Replaceable by 1N4152	
D134	152-0246-00			Silicon	Low leakage	0.25 W, 40 V
D135	152-0246-00			Silicon	Low leakage	0.25 W, 40 V
D158	152-0226-00			Zener	1N751A	0.4 W, 5.1 V, 5%
D160	152-0246-00			Silicon	Low leakage	0.25 W, 40 V
D171	152-0075-00			Germanium	Tek Spec	
D172	152-0075-00			Germanium	Tek Spec	
D180	*152-0185-00			Silicon	Replaceable by 1N4152	

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D183	152-0079-00			Germanium	HD1841
D207	*152-0328-00			Silicon	FET Tek Spec
D208	*152-0328-00			Silicon	FET Tek Spec
D223	*152-0185-00			Silicon	Replaceable by 1N4152
D235	152-0246-00			Silicon	Low leakage 0.25 W, 40 V
D236	152-0246-00			Silicon	Low leakage 0.25 W, 40 V
D260	152-0246-00			Silicon	Low leakage 0.25 W, 40 V
D280	*152-0185-00			Silicon	Replaceable by 1N4152
D283	152-0079-00			Germanium	HD1841
D304	*152-0185-00			Silicon	Replaceable by 1N4152
D308	*152-0185-00			Silicon	Replaceable by 1N4152
D313	*152-0185-00			Silicon	Replaceable by 1N4152
D318	*152-0185-00			Silicon	Replaceable by 1N4152
D319	*152-0185-00			Silicon	Replaceable by 1N4152
D329	*152-0107-00			Silicon	Replaceable by 1N647
D332	*152-0185-00			Silicon	Replaceable by 1N4152
D356	*152-0185-00			Silicon	Replaceable by 1N4152
D362	*152-0185-00			Silicon	Replaceable by 1N4152
D368	*152-0185-00			Silicon	Replaceable by 1N4152
D369	152-0246-00			Silicon	Low leakage 0.25 W, 40 V
D396	152-0166-00			Zener	1N753A 0.4 W, 6.2 V, 5%
D407	*152-0185-00			Silicon	Replaceable by 1N4152
D410	152-0079-00			Germanium	HD1841
D437	*152-0185-00			Silicon	Replaceable by 1N4152
D440	152-0079-00			Germanium	HD1841
D527	*152-0185-00			Silicon	Replaceable by 1N4152
D528	*152-0185-00			Silicon	Replaceable by 1N4152
D531	152-0170-00			Silicon	1N4441
D532	152-0170-00			Silicon	1N4441
D533	152-0170-00			Silicon	1N4441
D534	152-0170-00			Silicon	1N4441
D535	152-0170-00			Silicon	1N4441
D536	152-0170-00			Silicon	1N4441
D540	152-0170-00			Silicon	1N4441
D546	152-0170-00			Silicon	1N4441
D560	*152-0185-00			Silicon	Replaceable by 1N4152
D562	*152-0185-00			Silicon	Replaceable by 1N4152
D565	*152-0185-00			Silicon	Replaceable by 1N4152
D590	152-0168-00			Zener	1N963A 0.4 W, 12 V, 20%

Connector

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
J349	131-0407-00			Jack, Telephone Spring Leaf	

Inductor

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
L555A,B,C,D	*108-0448-01			CRT Deflection	

Loudspeaker

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
LS349	119-0131-00			Loudspeaker, P.M. 100 Ω, 0.25 W	

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q109	*151-1013-00			Silicon	FET Dual, Tek Spec
Q110	151-0188-00			Silicon	2N3906
Q111	151-0190-00			Silicon	2N3904
Q119	151-0190-00			Silicon	2N3904
Q122	151-0188-00			Silicon	2N3906
Q137	*151-1013-00			Silicon	FET Dual, Tek Spec
Q145	*151-0192-00			Silicon	Replaceable by MPS-6521
Q151	151-0190-00			Silicon	2N3904
Q154	151-0188-00			Silicon	2N3906
Q160	151-0188-00			Silicon	2N3906
Q175	*151-0192-00			Silicon	Replaceable by MPS-6521
Q180	151-0164-00			Silicon	2N3702
Q186	151-0164-00			Silicon	2N3702
Q211	*151-1004-00			Silicon	FET Tek Spec
Q215	151-0150-00			Silicon	2N3440
Q219	151-0190-00			Silicon	2N3904
Q222	151-0188-00			Silicon	2N3906
Q245	*151-0192-00			Silicon	Replaceable by MPS-6521
Q254	151-0188-00			Silicon	2N3906
Q260	151-0188-00			Silicon	2N3906
Q275	*151-0192-00			Silicon	Replaceable by MPS-6521
Q280	151-0164-00			Silicon	2N3702
Q286	151-0164-00			Silicon	2N3702
Q311	*151-0192-00			Silicon	Replaceable by MPS-6521
Q320	*151-0216-00			Silicon	Replaceable by MOT MPS-6523
Q330	*151-0216-00			Silicon	Replaceable by MOT MPS-6523
Q335	*151-0192-00			Silicon	Replaceable by MPS-6521
Q339	151-0190-00			Silicon	2N3904
Q341	151-0190-00			Silicon	2N3904
Q347	*151-0192-00			Silicon	Replaceable by MPS-6521
Q348	*151-0216-00			Silicon	Replaceable by MOT MPS-6523
Q351	151-0190-00			Silicon	2N3904

Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q360	151-0188-00			Silicon	2N3906
Q377	*151-1004-00			Silicon	FET Tek Spec
Q380	151-0188-00			Silicon	2N3906
Q385	151-0190-00			Silicon	2N3904
Q401	*151-0192-00			Silicon	Replaceable by MPS-6521
Q406	151-0164-00			Silicon	2N3702
Q412	151-0164-00			Silicon	2N3702
Q431	*151-0192-00			Silicon	Replaceable by MPS-6521
Q436	151-0164-00			Silicon	2N3702
Q442	151-0164-00			Silicon	2N3702
Q507	151-0190-00			Silicon	2N3904
Q510	*151-0216-00			Silicon	Replaceable by MOT MPS-6523
Q521	*151-0136-00			Silicon	Replaceable by 2N3053
Q523	*151-0136-00			Silicon	Replaceable by 2N3053
Q560	*151-0188-01			Silicon	Replaceable by 2N3251

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R11	315-0243-00			24 kΩ	¼ W		5%
R12	315-0473-00			47 kΩ	¼ W		5%
R14	315-0243-00			24 kΩ	¼ W		5%
R15	315-0473-00			47 kΩ	¼ W		5%
R16	315-0243-00			24 kΩ	¼ W		5%
R17	315-0473-00			47 kΩ	¼ W		5%
R19	315-0163-00			16 kΩ	¼ W		5%
R21	316-0225-00			2.2 MΩ	¼ W		
R23	316-0225-00			2.2 MΩ	¼ W		
R31	301-0620-00	B010100	B059999	62 Ω	½ W		5%
R31	308-0500-00	B060000		62 Ω	3 W		5%
R33	301-0620-00	B010100	B059999	62 Ω	½ W		5%
R33	308-0500-00	B060000		62 Ω	3 W		5%
R101	308-0291-00			2 kΩ	3 W	WW	5%
R104	315-0102-00	B010100	B109999	1 kΩ	¼ W		5%
R104	308-0077-00	B110000		1 kΩ	3 W	WW	5%
R105	316-0336-00			33 MΩ	¼ W		
R106	302-0100-00			10 Ω	½ W		
R107	315-0106-00			10 MΩ	¼ W		5%
R110	321-0404-00			158 kΩ	⅛ W	Prec	1%
R112	321-0354-00			47.5 kΩ	⅛ W	Prec	1%
R114	321-0372-00			73.2 kΩ	⅛ W	Prec	1%
R119	321-0324-00			23.2 kΩ	⅛ W	Prec	1%
R121	321-0373-00			75 kΩ	⅛ W	Prec	1%
R124	311-0464-00	B010100	B139999	25 kΩ, Var			
R124	311-1231-00	B140000		25 kΩ, Var			
R126	321-0324-00			23.2 kΩ	⅛ W	Prec	1%
R127	321-0369-00			68.1 kΩ	⅛ W	Prec	1%
R131	321-0308-00	B010100	B010129	15.8 kΩ	⅛ W	Prec	1%
R131	321-0309-00	B010130		16.2 kΩ	⅛ W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R132	321-0209-00			1.47 kΩ	1/8 W	Prec	1%
R134	316-0225-00			2.2 MΩ	1/4 W		
R136	321-0385-00			100 kΩ	1/8 W	Prec	1%
R137	321-0251-00			4.02 kΩ	1/8 W	Prec	1%
R139	311-0607-00			10 kΩ, Var			
R141	321-0353-00			46.4 kΩ	1/8 W	Prec	1%
R145	321-0356-00			49.9 kΩ	1/8 W	Prec	1%
R147	315-0474-00			470 kΩ	1/4 W		5%
R148	321-0240-00			3.09 kΩ	1/8 W	Prec	1%
R149	311-0162-00			1 MΩ, Var			
R154	321-0335-00			30.1 kΩ	1/8 W	Prec	1%
R156	321-0371-00			71.5 kΩ	1/8 W	Prec	1%
R160	316-0685-00			6.8 MΩ	1/4 W		
R162	321-0385-00			100 kΩ	1/8 W	Prec	1%
R165	315-0332-00			3.3 kΩ	1/4 W		5%
R170	315-0185-00			1.8 MΩ	1/4 W		5%
R171	315-0433-00			43 kΩ	1/4 W		5%
R172	315-0433-00			43 kΩ	1/4 W		5%
R173	315-0185-00			1.8 kΩ	1/4 W		5%
R175	315-0563-00			56 kΩ	1/4 W		5%
R177	325-0022-00			7.5 Ω	1/2 W	Prec	1%
R178	307-0126-00			100 Ω	Thermal		
R185	315-0182-00			1.8 kΩ	1/4 W		5%
R191	315-0330-00			33 Ω	1/4 W		5%
R201	308-0291-00			2 kΩ	3 W	WW	5%
R206	302-0100-00			10 Ω	1/2 W		
R207	315-0106-00			10 MΩ	1/4 W		5%
R210	321-0316-00			19.1 kΩ	1/8 W	Prec	1%
R212	311-0607-00			10 kΩ, Var			
R213	321-0279-00			7.87 kΩ	1/8 W	Prec	1%
R215	321-0238-00			2.94 kΩ	1/8 W	Prec	1%
R217	316-0226-00			22 MΩ	1/4 W		
R218	311-0613-00			100 kΩ, Var			
R219	321-0324-00			23.2 kΩ	1/8 W	Prec	1%
R221	321-0373-00			75 kΩ	1/8 W	Prec	1%
R224	315-0183-00			18 kΩ		Selected (nominal value)	
R227	321-0369-00			68.1 kΩ	1/8 W	Prec	1%
R234	316-0225-00			2.2 MΩ	1/4 W		
R236	321-0385-00			100 kΩ	1/8 W	Prec	1%
R237	321-0251-00			4.02 kΩ	1/8 W	Prec	1%
R245	321-0356-00			49.9 kΩ	1/8 W	Prec	1%
R247	315-0474-00			470 kΩ	1/4 W		5%
R248	321-0240-00			3.09 kΩ	1/8 W	Prec	1%
R249	311-0677-00	B010100	B059999	150 kΩ, Var			
R249	311-0677-01	B060000		150 kΩ, Var	1/4 W		10%
R254	321-0335-00			30.1 kΩ	1/8 W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R256	321-0371-00			71.5 kΩ	⅛ W	Prec	1%
R260	316-0685-00			6.8 MΩ	¼ W		
R262	321-0385-00			100 kΩ	⅛ W	Prec	1%
R265	315-0332-00			3.3 kΩ	¼ W		5%
R275	315-0563-00			56 kΩ	¼ W		5%
R285	315-0182-00			1.8 kΩ	¼ W		5%
R301	315-0103-00			10 kΩ	¼ W		5%
R302	315-0272-00			2.7 kΩ	¼ W		5%
R304	315-0134-00			130 kΩ	¼ W		5%
R306	315-0272-00			2.7 kΩ	¼ W		5%
R307	315-0103-00			10 kΩ	¼ W		5%
R308	315-0134-00			130 kΩ	¼ W		5%
R309	315-0335-00			3.3 MΩ	¼ W		5%
R311	316-0156-00			15 MΩ	¼ W		
R313	315-0684-00			680 kΩ	¼ W		5%
R314	315-0335-00			3.3 MΩ	¼ W		5%
R317	315-0105-00			1 MΩ	¼ W		5%
R319	315-0106-00			10 MΩ	¼ W		5%
R321	315-0333-00			33 kΩ	¼ W		5%
R322	315-0104-00			100 kΩ	¼ W		5%
R324	315-0153-00			15 kΩ	¼ W		5%
R326	315-0105-00			1 MΩ	¼ W		5%
R328	315-0155-00			1.5 MΩ	¼ W		5%
R329	316-0125-00			1.2 MΩ	¼ W		
R331	315-0393-00			39 kΩ	¼ W		5%
R332	315-0333-00			33 kΩ	¼ W		5%
R333	316-0565-00			5.6 MΩ	¼ W		
R335	315-0822-00			8.2 kΩ	¼ W		5%
R336	315-0103-00			10 kΩ	¼ W		5%
R338	315-0123-00			12 kΩ	¼ W		5%
R339	315-0123-00			12 kΩ	¼ W		5%
R340	315-0222-00			2.2 kΩ	¼ W		5%
R342	315-0103-00			10 kΩ	¼ W		5%
R344	315-0103-00			10 kΩ	¼ W		5%
R345	311-0310-00			5 kΩ, Var			
R346	315-0103-00			10 kΩ	¼ W		5%
R348	315-0100-00			10 Ω	¼ W		5%
R349	315-0100-00			10 Ω	¼ W		5%
R351	321-0382-00			93.1 kΩ	⅛ W	Prec	1%
R352	321-0405-00			162 kΩ	⅛ W	Prec	1%
R353	315-0124-00			120 kΩ	¼ W		5%
R356	315-0103-00			10 kΩ	¼ W		5%
R358	315-0123-00			12 kΩ	¼ W		5%
R359	315-0473-00			47 kΩ	¼ W		5%
R361	321-0240-00			3.09 kΩ	⅛ W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R362	321-0266-00			5.75 kΩ	1/8 W	Prec	1%
R364	315-0243-00			24 kΩ	1/4 W		5%
R366	315-0105-00			1 MΩ	1/4 W		5%
R368	315-0472-00			4.7 kΩ	1/4 W		5%
R370	309-0093-00			4 MΩ	1/2 W	Prec	1%
R371	325-0005-00			1.985 MΩ	1/2 W	Prec	1/2%
R372	322-0630-00			980 kΩ	1/4 W	Prec	1%
R374	321-0330-00			26.7 kΩ	1/8 W	Prec	1%
R375	311-0614-00			30 kΩ, Var			
R376	321-0290-00	B010100	B069999	10.2 kΩ	1/8 W	Prec	1%
R376	321-0302-00	B070000		13.7 kΩ	1/8 W	Prec	1%
R377	315-0393-00			39 kΩ	1/4 W		5%
R380	315-0154-00			150 kΩ	1/4 W		5%
R382	315-0513-00			51 kΩ	1/4 W		5%
R383	315-0333-00			33 kΩ	1/4 W		5%
R385	315-0512-00			5.1 kΩ	1/4 W		5%
R390	311-0614-00			30 kΩ, Var			
R391	321-0306-00			15 kΩ	1/8 W	Prec	1%
R392	311-0624-00	B010100	B139999	200 kΩ, Var			
R392	311-1251-00	B140000		200 kΩ, Var			
R393	321-0376-00			80.6 kΩ	1/8 W	Prec	1%
R394	321-0265-00			5.62 kΩ	1/8 W	Prec	1%
R396	315-0302-00			3 kΩ	1/4 W		5%
R397	311-0635-00			1 kΩ, Var			
R399	315-0202-00			2 kΩ	1/4 W		5%
R401	315-0823-00			82 kΩ	1/4 W		5%
R403	315-0472-00			4.7 kΩ	1/4 W		5%
R411	315-0182-00			1.8 kΩ	1/4 W		5%
R419	321-0168-00			549 Ω	1/8 W	Prec	1%
R423	315-0101-00			100 Ω	1/4 W		5%
R424	321-0097-00			100 Ω	1/8 W	Prec	1%
R425	307-0127-00			1 kΩ	Thermal		
R431	315-0823-00			82 kΩ	1/4 W		5%
R433	321-0265-00			5.62 kΩ	1/8 W	Prec	1%
R434	321-0385-00			100 kΩ	1/8 W	Prec	1%
R436	315-0472-00			4.7 kΩ	1/4 W		5%
R441	315-0182-00			1.8 kΩ	1/4 W		5%
R449	321-0168-00			549 Ω	1/8 W	Prec	1%
R496	315-0334-00	B010100	B099999X	330 kΩ	1/4 W		5%
R501	315-0204-00			200 kΩ	1/4 W		5%
R502	311-0465-00	B010100	B139999	100 kΩ, Var			
R502	311-1235-00	B140000		100 kΩ, Var			
R503	315-0134-00			130 kΩ	1/4 W		5%
R507	315-0473-00			47 kΩ	1/4 W		5%
R509	315-0222-00			2.2 kΩ	1/4 W		5%
R510	315-0124-00			120 kΩ	1/4 W		5%
R512	315-0102-00			1 kΩ	1/4 W		5%
R519	316-0470-00	XB090000		47 Ω	1/4 W		
R520	316-0470-00	XB090000		47 Ω	1/4 W		
R522	315-0331-00			330 Ω	1/4 W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R538	316-0225-00			2.2 MΩ	¼ W	
R550	311-0637-00	B010100	B139999	2.5 MΩ, Var		
R550	311-1256-00	B140000		2.5 MΩ, Var		
R563	316-0685-00			6.8 MΩ	¼ W	
R565	316-0825-00			8.2 MΩ	¼ W	
R590	315-0683-00			68 kΩ	¼ W	5%
R597	307-0104-00			3.3 Ω	¼ W	5%

Switches

Ckt. No.	Unwired or Wired	Part No.	Description	
SW15	wired	*262-0817-00	Rotary	ECG LEAD SELECTOR
SW15		260-0870-00	Rotary	ECG LEAD SELECTOR
SW25	wired	*262-0818-00	Rotary	INPUT SELECTOR
SW25		260-0871-00	Rotary	INPUT SELECTOR
SW380	wired	*262-0819-00	Rotary	SWEEP SPEED
SW380		260-0872-00	Rotary	SWEEP SPEED

Test Points

TP120	*214-0579-00	Connector, Test Point
TP194	*214-0579-00	Connector, Test Point
TP495	*214-0579-00	Connector, Test Point
TP527	*214-0579-00	Connector, Test Point
TP595	*214-0579-00	Connector, Test Point

Transformer

T530	*120-0496-00	H. V. Power

Electron Tube

V555	154-0508-00	B010100	B169999	CRT, Rect. Aluminized Screen
V555	154-0508-01	B170000		CRT, Rect. Aluminized Screen

BATTERY PACK

*016-0107-00	B010100	B099999	Complete Battery Pack

Capacitor

C615	290-0324-00	750 μF	Elect.	40 V	+75%—10%

Diodes

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D611A,B,C,D(4)	*152-0107-00			Silicon	Replaceable by 1N647
D621	*152-0107-00			Silicon	Replaceable by 1N647

Fuses

F601(2)	159-0060-00	0.1 A, 125 V Miniature
F602(2)	159-0060-00	0.1 A, 125 V Miniature
F641(2)	159-0059-00	5 A, 125 V Miniature
F643(2)	159-0059-00	5 A, 125 V Miniature

Connectors

J641	131-0031-00	Jack, Banana Non-Insulated
J642	131-0031-00	Jack, Banana Non-Insulated
J643	131-0031-00	Jack, Banana Non-Insulated
P601	*204-0301-00	Body, Connector

Transistors

Q627	151-0190-00	Silicon	2N3904
Q633	*151-0148-00	Silicon	Selected (RCA 40250)

Resistors

R604	308-0075-00	100 Ω	3 W	WW	5%
R605	308-0075-00	100 Ω	3 W	WW	5%
R625	301-0362-00	3.6 kΩ	½ W		5%
R635	325-0023-00	3.8 Ω	½ W	Prec	1%

Switch

	Unwired or Wired		
SW603	260-0675-01	Slide	DPDT

Transformer

T601	*120-0495-00	L.V. Power

BATTERY PACK

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*016-0107-02	B100000		Complete Battery Pack Model 1 & 2			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C615	290-0324-00			750 μF	Elect.	40 V	+75%—10%
C650	283-0005-00			0.01 μF	Cer	250 V	
C682	283-0178-00			0.1 μF	Cer	100 V	+80%—20%

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
D611	*152-0107-00			Silicon	Replaceable by 1N647
D612	*152-0107-00			Silicon	Replaceable by 1N647
D613	*152-0107-00			Silicon	Replaceable by 1N647
D614	*152-0107-00			Silicon	Replaceable by 1N647
D625	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D626	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D640	*152-0107-00			Silicon	Replaceable by 1N647
D641	152-0438-00			Zener	750 mW, 9.1 V, 5%
D643	152-0438-00			Zener	750 mW, 9.1 V, 5%
D650	*152-0185-00			Silicon	Replaceable by 1N4152
D662	152-0227-00			Zener	1N753A 400 mW, 6.2 V, 5%
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	Replaceable by 1N4152
D688	152-0079-00	B100000	B159999	Germanium	HD1841
D688	152-0075-00	B160000		Germanium	ED48 or GD238

Fuses

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
F601 (2)	159-0090-00			0.25 A	125 V, miniature
F602 (2)	159-0090-00			0.25 A	125 V, miniature
F641 (2)	159-0059-00			5 A	125 V, miniature
F643 (2)	159-0059-00			5 A	125 V, miniature

Connectors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
J641	131-0031-00			Jack, Banana, Non-Insulated
J642	131-0031-00			Jack, Banana, Non-Insulated
J643	131-0031-00			Jack, Banana, Non-Insulated
P601	131-0859-00			Plug, electrical

Relay

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
K670	*148-0059-00			Mag Latch, 125 Ω

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q625	151-0220-00			Silicon	2N4122
Q627	151-0190-00			Silicon	2N3904
Q633	*151-0148-00			Silicon	Selected (RCA 40250)
Q650	151-0164-00			Silicon	2N3702
Q654	*151-0216-00			Silicon	Replaceable by MPS 6523
Q662	151-0190-00			Silicon	2N3904
Q680	151-0190-00			Silicon	2N3904
Q682	*151-0216-00			Silicon	Replaceable by MPS 6523
Q683	151-0164-00			Silicon	2N3702
Q688	151-1025-00			Silicon	FET, N channel, junction type

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R625	317-0122-00	1.2 kΩ	1/8 W	5%
R626	317-0561-00	560 Ω	1/8 W	5%
R628	317-0361-00	360 Ω	1/8 W	5%
R631	311-0901-00	250 Ω, Var		
R633	315-0474-00	470 kΩ	1/4 W	5%
R635	307-0053-00	3.3 Ω	1/2 W	5%
R653	317-0474-00	470 kΩ	1/8 W	5%
R654	317-0164-00	160 kΩ	1/8 W	5%
R660	317-0473-00	47 kΩ	1/8 W	5%
R662	311-0904-00	50 kΩ, Var		
R664	317-0103-00	10 kΩ	1/8 W	5%
R666	317-0753-00	75 kΩ	1/8 W	5%
R680	317-0333-00	33 kΩ	1/8 W	5%
R681	317-0272-00	2.7 kΩ	1/8 W	5%
R682	317-0474-00	470 Ω	1/8 W	5%

Switch

	Unwired or Wired		
SW603	260-0675-01	Slide	DPDT

Transformer

T601	*120-0647-00	L. V. Power

BATTERY PACK

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*016-0107-02	B100000		Complete Battery Pack—Model 3			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C615	290-0324-00			750 μF	Elect.	40 V	+75%—10%
C651	290-0114-00			47 μF	Elect.	6 V	
C682	283-0178-00			0.1 μF	Cer	100 V	+80%—20%

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
D611	*152-0107-00			Silicon	Replaceable by 1N647
D612	*152-0107-00			Silicon	Replaceable by 1N647
D613	*152-0107-00			Silicon	Replaceable by 1N647
D614	*152-0107-00			Silicon	Replaceable by 1N647
D625	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D626	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D640	*152-0107-00			Silicon	Replaceable by 1N647
D641	152-0438-00			Zener	750 mW, 9.1 V, 5%
D643	152-0438-00			Zener	750 mW, 9.1 V, 5%
D650	*152-0185-00			Silicon	Replaceable by 1N4152
D662	152-0227-00			Zener	1N753A 400 mW, 6.2 V, 5%
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	Replaceable by 1N4152
D688	152-0079-00	B100000	B159999	Germanium	HD1841
D688	152-0075-00	B160000		Germanium	ED48 or GD238

Fuses

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
F601 (2)	159-0090-00			0.25 A	125 V, miniature
F602 (2)	159-0090-00			0.25 A	125 V, miniature
F641 (2)	159-0059-00			5 A	125 V, miniature
F643 (2)	159-0059-00			5 A	125 V, miniature

Connectors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
J641	131-0031-00			Jack, Banana, Non-Insulated
J642	131-0031-00			Jack, Banana, Non-Insulated
J643	131-0031-00			Jack, Banana, Non-Insulated
P601	131-0859-00			Plug, electrical

Relay

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
K670	*148-0059-00			Mag Latch, 125 Ω

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q625	151-0220-00			Silicon	2N4122
Q627	151-0190-00			Silicon	2N3904
Q633	*151-0148-00			Silicon	Selected (RCA 40250)
Q650	151-0164-00			Silicon	2N3702
Q654	*151-0216-00			Silicon	Replaceable by MPS 6523
Q662	151-0190-00			Silicon	2N3904
Q680	151-0190-00			Silicon	2N3904
Q682	*152-0216-00			Silicon	Replaceable by MPS 6523
Q683	151-0164-00			Silicon	2N3702
Q688	151-1025-00			Silicon	FET, N channel, junction type

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R625	317-0122-00	1.2 kΩ	1/8 W	5%
R626	317-0561-00	560 Ω	1/8 W	5%
R628	317-0361-00	360 Ω	1/8 W	5%
R631	311-0901-00	250 Ω, Var		
R633	315-0474-00	470 kΩ	1/4 W	5%
R635	307-0053-00	3.3 Ω	1/2 W	5%
R653	317-0474-00	470 kΩ	1/8 W	5%
R654	317-0164-00	160 kΩ	1/8 W	5%
R660	317-0473-00	47 kΩ	1/8 W	5%
R662	311-0904-00	50 kΩ, Var		
R664	317-0103-00	10 kΩ	1/8 W	5%
R666	317-0753-00	75 kΩ	1/8 W	5%
R680	317-0333-00	33 kΩ	1/8 W	5%
R681	317-0272-00	2.7 kΩ	1/8 W	5%
R682	317-0474-00	470 kΩ	1/8 W	5%

Switch

	Unwired or Wired		
SW603	260-0675-01	Slide	DPDT

Transformer

T601	*120-0647-00	L. V. Power

BATTERY PACK

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*016-0107-02	B100000		Complete Battery Pack Model 4			

Capacitors

Tolerance ±20% unless otherwise indicated.

C615	290-0324-00			750 μF	Elect.	40 V	+75%—10%
C651	290-0167-00			10 μF	Elect.	15 V	
C665	283-0000-00			0.001 μF	Cer	500 V	

Semiconductor Device, Diodes

D611	*152-0107-00			Silicon	Replaceable by 1N647
D612	*152-0107-00			Silicon	Replaceable by 1N647
D613	*152-0107-00			Silicon	Replaceable by 1N647
D614	*152-0107-00			Silicon	Replaceable by 1N647
D625	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D626	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D640	*152-0107-00			Silicon	Replaceable by 1N647
D641	152-0438-00			Zener	750 mW, 9.1 V, 5%
D643	152-0438-00			Zener	750 mW, 9.1 V, 5%
D650	*152-0185-00			Silicon	Replaceable by 1N4152
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	
D680	152-0227-00			Zener	1N753A 400 mW, 6.2 V, 5%
D684	*152-0185-00			Silicon	Replaceable by 1N4152
D688	152-0079-00	B100000	B159999	Germanium	HD1841
D688	152-0075-00	B160000		Germanium	ED48 or GD238

Fuses

F601 (2)	150-0090-00	0.25 A	125 V, miniature
F602 (2)	159-0090-00	0.25 A	125 V, miniature
F641 (2)	159-0059-00	5 A	125 V, miniature
F643 (2)	159-0059-00	5 A	125 V, miniature

Connectors

J641	131-0031-00	Jack, Banana, Non-Insulated
J642	131-0031-00	Jack, Banana, Non-Insulated
J643	131-0031-00	Jack, Banana, Non-Insulated
P601	131-0859-00	Plug, electrical

Relay

K670	*148-0059-01	Mag Latch, 125 Ω

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q625	151-0220-00			Silicon	2N4122
Q627	151-0190-00			Silicon	2N3904
Q633	*151-0148-00			Silicon	Selected (RCA 40250)
Q654	151-0508-00			Silicon	D13T1
Q659	151-0190-00			Silicon	2N3904
Q666	*151-0192-00			Silicon	Replaceable by MPS 6521
Q670	151-0164-00			Silicon	2N3702
Q684	*151-0192-00			Silicon	Replaceable by MPS 6521
Q686	151-0164-00			Silicon	2N3702
Q688	151-1025-00			Silicon	FET, N channel, junction type

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R625	317-0122-00	1.2 kΩ	1/8 W	5%
R626	317-0561-00	560 Ω	1/8 W	5%
R628	317-0361-00	360 Ω	1/8 W	5%
R631	311-0901-00	250 Ω, Var		
R633	315-0474-00	470 kΩ	1/4 W	5%
R635	307-0104-00	3.3 Ω	1/4 W	5%
R651	317-0105-00	1 MΩ	1/8 W	5%
R654	317-0561-00	560 Ω	1/8 W	5%
R656	317-0753-00	75 kΩ	1/8 W	5%
R657	317-0134-00	130 kΩ	1/8 W	5%
R658	317-0332-00	3.3 kΩ	1/8 W	5%
R659	317-0682-00	6.8 kΩ	1/8 W	5%
R660	317-0393-00	39 kΩ	1/8 W	5%
R662	311-0906-00	20 kΩ, Var		
R664	317-0473-00	47 kΩ	1/8 W	5%
R665	317-0684-00	680 kΩ	1/8 W	5%
R666	317-0472-00	4.7 kΩ	1/8 W	5%
R680	317-0333-00	33 kΩ	1/8 W	5%
R682	317-0273-00	27 kΩ	1/8 W	5%
R683	317-0514-00	510 kΩ	1/8 W	5%
R684	317-0472-00	4.7 kΩ	1/8 W	5%

Switch

	Unwired or Wired		
SW603	260-0675-01	Slide	DPDT

Transformer

T601	*120-0647-00	L. V. Power

BATTERY PACK

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*016-0107-02	B100000		Complete Battery Pack Model 5			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C615	290-0324-00			750 μF	Elect.	40 V	+75%—10%
C626	283-0000-00			0.001 μF	Cer	500 V	
C651	290-0167-00			10 μF	Elect.	15 V	
C665	283-0000-00			0.001 μF	Cer	500 V	

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
D611	*152-0107-00			Silicon	Replaceable by 1N647
D612	*152-0107-00			Silicon	Replaceable by 1N647
D613	*152-0107-00			Silicon	Replaceable by 1N647
D614	*152-0107-00			Silicon	Replaceable by 1N647
D625	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D626	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D640	*152-0107-00			Silicon	Replaceable by 1N647
D641	152-0438-00			Zener	750 mW, 9.1 V, 5%
D643	152-0438-00			Zener	750 mW, 9.1 V, 5%
D650	*152-0185-00			Silicon	Replaceable by 1N4152
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	Replaceable by 1N4152
D680	152-0227-00			Zener	1N753A 400 mW, 6.2 V, 5%
D684	*152-0185-00			Silicon	Replaceable by 1N4152
D688	152-0079-00	B100000	B159999	Germanium	HD1841
D688	152-0075-00	B160000		Germanium	ED48 or GD238

Fuses

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
F601 (2)	159-0090-00			0.25 A	125 V, miniature
F602 (2)	159-0090-00			0.25 A	125 V, miniature
F641 (2)	159-0059-00			5 A	125 V, miniature
F643 (2)	159-0059-00			5 A	125 V, miniature

Connectors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
J641	131-0031-00			Jack, Banana, Non-Insulated
J642	131-0031-00			Jack, Banana, Non-Insulated
J643	131-0031-00			Jack, Banana, Non-Insulated
P601	131-0859-00			Plug, electrical

Relay

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
K670	*148-0059-01			Mag Latch, 125 Ω		

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
Q625	151-0220-00			Silicon	2N4122	
Q627	151-0190-00			Silicon	2N3904	
Q633	*151-0148-00			Silicon	Selected (RCA 40250)	
Q654	151-0508-00			Silicon	D13T1	
Q659	151-0190-00			Silicon	2N3904	
Q666	*151-0192-00			Silicon	Replaceable by MPS 6521	
Q670	151-0164-00			Silicon	2N3702	
Q684	*151-0192-00			Silicon	Replaceable by MPS 6521	
Q686	151-0164-00			Silicon	2N3702	
Q688	151-1025-00			Silicon	FET, N channel, junction type	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
R625	317-0122-00			1.2 kΩ	1/8 W	5%
R626	317-0561-00			560 Ω	1/8 W	5%
R628	317-0361-00			360 Ω	1/8 W	5%
R631	311-0901-00			250 Ω, Var		
R633	315-0474-00			470 kΩ	1/4 W	5%
R635	307-0104-00			3.3 Ω	1/4 W	5%
R651	317-0105-00			1 MΩ	1/8 W	5%
R654	317-0561-00			560 Ω	1/8 W	5%
R656	317-0753-00			75 kΩ	1/8 W	5%
R657	317-0134-00			130 kΩ	1/8 W	5%
R658	317-0332-00			3.3 kΩ	1/8 W	5%
R659	317-0682-00			6.8 kΩ	1/8 W	5%
R660	317-0393-00			39 kΩ	1/8 W	5%
R662	311-0906-00			20 kΩ, Var		
R664	317-0473-00			47 kΩ	1/8 W	5%
R665	317-0684-00			680 kΩ	1/8 W	5%
R666	317-0472-00			4.7 kΩ	1/8 W	5%
R680	317-0333-00			33 kΩ	1/8 W	5%
R682	317-0273-00			27 kΩ	1/8 W	5%
R683	317-0514-00			510 kΩ	1/8 W	5%
R684	317-0472-00			4.7 kΩ	1/8 W	5%

Switch

Unwired or Wired

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
SW603	260-0675-01			Slide	DPDT	

Transformer

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
T601	*120-0647-00			L. V. Power		

BATTERY PACK

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
	*016-0107-02	B100000		Complete Battery Pack Model 6-up			

Capacitors

Tolerance ±20% unless otherwise indicated.

C615	290-0324-00			750 μF	Elect.	40 V	+75%—10%
C626	283-0000-00			0.001 μF	Cer	500 V	
C651	290-0167-00			10 μF	Elect.	15 V	
C665	283-0000-00			0.001 μF	Cer	500 V	

Semiconductor Device, Diodes

D611	*152-0107-00			Silicon	Replaceable by 1N647
D612	*152-0107-00			Silicon	Replaceable by 1N647
D613	*152-0107-00			Silicon	Replaceable by 1N647
D614	*152-0107-00			Silicon	Replaceable by 1N647
D625	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D626	152-0437-00			Zener	400 mW, 8.2 V, 2%, 10 mA
D640	*152-0107-00			Silicon	Replaceable by 1N647
D641	152-0438-00			Zener	750 mW, 9.1 V, 5%
D643	152-0438-00			Zener	750 mW, 9.1 V, 5%
D650	*152-0185-00			Silicon	Replaceable by 1N4152
D670	*152-0185-00			Silicon	Replaceable by 1N4152
D671	*152-0185-00			Silicon	Replaceable by 1N4152
D680	152-0227-00			Zener	1N753A 400 mW, 6.2 V, 5%
D684	*152-0185-00			Silicon	Replaceable by 1N4152
D688	152-0079-00	B100000	B159999	Germanium	HD1841
D688	152-0075-00	B160000		Germanium	ED48 or GD238

Fuses

F601 (2)	159-0090-00	0.25 A	125 V, miniature
F602 (2)	159-0090-00	0.25 A	125 V, miniature
F641 (2)	159-0059-00	5 A	125 V, miniature
F643 (2)	159-0059-00	5 A	125 V, miniature

Connectors

J641	131-0031-00	Jack, Banana, Non-Insulated
J642	131-0031-00	Jack, Banana, Non-Insulated
J643	131-0031-00	Jack, Banana, Non-Insulated
P601	131-0859-00	Plug, electrical

Relay

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
K670	*148-0059-01			Mag Latch, 125 Ω		

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
Q625	151-0220-00			Silicon	2N4122	
Q627	151-0190-00			Silicon	2N3904	
Q633	*151-0148-00			Silicon	Selected (RCA 40250)	
Q654	151-0508-00			Silicon	D13T1	
Q659	151-0190-00			Silicon	2N3904	
Q666	*151-0192-00			Silicon	Replaceable by MPS 6521	
Q670	151-0164-00			Silicon	2N3702	
Q684	*151-0192-00			Silicon	Replaceable by MPS 6521	
Q686	151-0164-00			Silicon	2N3702	
Q688	151-1025-00			Silicon	FET, N channel, junction type	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
R625	317-0122-00			1.2 kΩ	1/8 W	5%
R626	317-0561-00			560 Ω	1/8 W	5%
R628	317-0361-00			360 Ω	1/8 W	5%
R631	311-1278-00			250 Ω, Var		
R633	315-0474-00			470 kΩ	1/4 W	5%
R635	307-0104-00			3.3 Ω	1/4 W	5%
R651	317-0105-00			1 MΩ	1/8 W	5%
R654	317-0561-00			560 Ω	1/8 W	5%
R656	317-0753-00			75 kΩ	1/8 W	5%
R657	317-0134-00			130 kΩ	1/8 W	5%
R658	317-0332-00			3.3 kΩ	1/8 W	5%
R659	317-0682-00			6.8 kΩ	1/8 W	5%
R660	317-0393-00			39 kΩ	1/8 W	5%
R662	311-1284-00			20 kΩ, Var		
R664	317-0473-00			47 kΩ	1/8 W	5%
R665	317-0684-00			680 kΩ	1/8 W	5%
R666	317-0472-00			4.7 kΩ	1/8 W	5%
R680	317-0333-00			33 kΩ	1/8 W	5%
R682	317-0273-00			27 kΩ	1/8 W	5%
R683	317-0514-00			510 kΩ	1/8 W	5%
R684	317-0472-00			4.7 kΩ	1/8 W	5%

Switch

Ckt. No.	Unwired or Wired	Eff	Disc	Description		
SW603	260-0675-01			Slide	DPDT	

Transformer

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
T601	*120-0647-00			L. V. Power		

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

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SECTION 8
MECHANICAL PARTS LIST

FIG. 1 RIGHT SIDE & CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-1	366-0426-00			1	KNOB, blue—INPUT SELECTOR
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-2	262-0818-00			1	SWITCH, wired—INPUT SELECTOR
	- - - - - -			-	switch includes:
	260-0871-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
-3	214-0922-00			1	INSULATOR, plastic washer
-4	210-0865-00			1	WASHER, fiber, shouldered, $^3/_8$ ID x $^5/_8$ inch OD
-5	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
-6	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
	210-0951-00	XB050420		1	WASHER, locating
-7	366-0426-00			1	KNOB, blue—SWEEP SPEED
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-8	262-0819-00			1	SWITCH, wired—SWEEP SPEED
	- - - - - -			-	switch includes:
	260-0872-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0840-00			1	WASHER, flat, 0.390 ID x $^9/_{16}$ inch OD
-9	210-0413-00			1	NUT, hex., $^3/_8$-32 x $^1/_2$ inch
-10	358-0316-00			2	BUSHING, readout drum
	- - - - - -			-	each bushing includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-11	105-0055-02			1	DRUM, readout (INPUT SELECTOR switch)
	- - - - - -			-	drum includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-12	105-0055-01			1	DRUM, readout (SWEEP SPEED switch)
	- - - - - -			-	drum includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-13	366-0427-00			1	KNOB, blue—VERTICAL SIZE
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-14	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-1027-00			1	WASHER, flat, 0.252 ID x 0.405 inch OD
-15	214-0918-00			1	INSULATOR, plastic washer
-16	214-0917-00			1	DETENT, variable resistor
	210-0940-00			1	WASHER, flat, $^1/_4$ ID x $^3/_8$ inch OD
	210-0583-00			1	NUT, hex., $^1/_4$-32 x $^5/_{16}$ inch

FIG. 1 RIGHT SIDE & CHASSIS *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-17	366-0427-00			1	KNOB, blue—VERTICAL POSITION
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-18	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-1027-00	B010100	B059999X	1	WASHER, flat, 0.252 ID x 0.425 inch OD
	214-0918-00	B010100	B059999	1	INSULATOR, plastic washer
	214-0918-01	B060000		1	INSULATOR, plastic washer
-19	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-20	366-0427-00			1	KNOB, blue—ECG LEAD SELECTOR
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-21	262-0817-00			1	SWITCH, wired—ECG LEAD SELECTOR
	- - - - - -			-	switch includes:
	260-0870-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-1027-00			1	WASHER, flat, 0.252 ID x 0.405 inch OD
-22	214-0918-00	B010100	B059999	1	INSULATOR, plastic washer
	214-0918-01	B060000		1	INSULATOR, plastic washer
-23	210-1056-00			1	WASHER, fiber, shouldered, 1/4 ID x 1/2 inch OD
	210-0940-00			1	WASHER, flat, 1/4 ID x 1/2 OD x 0.40 inch thick
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-24	366-0427-00			1	KNOB, blue—LOUDNESS
	- - - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-25	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-1027-00			1	WASHER, flat, 0.252 ID x 0.405 inch OD
-26	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-27	200-0103-00			1	CAP, binding post
-28	355-0507-00			1	STEM, binding post
	- - - - - -			-	mounting hardware: (not included w/stem)
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-29	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-30	131-0407-00			1	JACK, w/mounting hardware
	- - - - - -			-	mounting hardware: (not included w/jack)
-31	210-1033-00			1	WASHER, fiber, shouldered, 0.193 ID x 0.344 inch OD
-32	210-1030-00			1	WASHER, fiber, 0.195 ID x 0.375 inch OD

FIG. 1 RIGHT SIDE & CHASSIS *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-33	119-0131-00			1	LOUDSPEAKER
	- - - - - -			-	mounting hardware: (not included w/loudspeaker)
-34	214-0919-00			2	RETAINER, loudspeaker
-35	213-0088-00			2	SCREW, thread forming, #4 x 1/4 inch, PHS
-36	333-1006-01			1	PANEL, side insert
-37	386-1276-00	B010100	B119999	1	PANEL, side
	386-1276-02	B120000		1	PANEL, side
	- - - - - -			-	mounting hardware: (not included w/panel)
-38	213-0055-00			4	SCREW, thread forming, 2-32 x 3/16 inch, PHS
-39	386-1246-01	B010100	B039999	1	SUB-PANEL, right side
	386-1246-06	B040000		1	SUB-PANEL, right side
	- - - - - -			-	sub-panel includes:
-40	348-0114-00	B010100	B039999	1	FOOT, cabinet, rubber
	354-0326-00	B040000		1	FOOT, cabinet, rubber
-41	214-0914-00			2	GASKET, cabinet side
-42	441-0738-00			1	CHASSIS, vertical
	- - - - - -			-	mounting hardware: (not included w/chassis)
-43	211-0538-00			3	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-44	210-0457-00			3	NUT, keps, 6-32 x 5/16 inch
-45	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-46	214-0920-00			4	SPRING, retaining
	- - - - - -			-	mounting hardware for each: (not included w/spring)
-47	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-48	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-49	348-0115-00			3	GROMMET, plastic, "U" shaped
-50	344-0133-00			19	CLIP, circuit board
	- - - - - -			-	mounting hardware for each: (not included w/clip)
-51	213-0088-00			1	SCREW, thread forming, #4 x 1/4 inch, PHS
-52	670-0530-00	B010100	B109999	1	ASSEMBLY, circuit board—VERTICAL AMPLIFIER
	670-0530-01	B110000		1	ASSEMBLY, circuit board—VERTICAL AMPLIFIER
	- - - - - -			-	assembly includes:
	388-0894-00	B010100	B109999	1	BOARD, circuit
	388-0894-01	B110000		1	BOARD, circuit
	131-0633-00	XB110000		2	TERMINAL, pin (not shown)
-53	343-0043-00			3	CLAMP, neon bulb
-54	214-0506-00			20	PIN, connector
-55	214-0579-00			2	PIN, test point
-56	136-0183-00			1	SOCKET, transistor, 3 pin
-57	136-0220-00			20	SOCKET, transistor, 3 pin
-58	136-0235-00			2	SOCKET, transistor, 6 pin
-59	441-0739-00			1	CHASSIS, high voltage
	- - - - - -			-	mounting hardware: (not included w/chassis)
-60	211-0558-00			1	SCREW, 6-32 x 1/4 inch, BH Plastic
-61	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
-62	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch

FIG. 1 RIGHT SIDE & CHASSIS *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-63	670-0528-00	B010100	B129999	1	ASSEMBLY, circuit board—HIGH VOLTAGE
	670-0528-01	B130000	B139999	1	ASSEMBLY, circuit board—HIGH VOLTAGE
	670-0528-02	B140000		1	ASSEMBLY, circuit board—HIGH VOLTAGE
	- - - - - -			-	assembly includes:
	388-0892-00	B010100	B129999	1	BOARD, circuit
	388-0892-01	B130000	B139999	1	BOARD, circuit
	388-0892-02	B140000		1	BOARD, circuit
-64	214-0506-00			11	PIN, connector
-65	214-0579-00			2	PIN, test point
-66	136-0183-00			2	SOCKET, transistor, 3 pin
-67	136-0220-00			3	SOCKET, transistor, 3 pin
-68	441-0737-00			1	CHASSIS, horizontal
	- - - - - -			-	mounting hardware: (not included w/chassis)
-69	211-0538-00			3	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch (not shown)
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch (not shown)
	210-0202-00			1	LUG, solder, SE #6 (not shown)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS (not shown)
	211-0040-00	XB140000		2	SCREW, 4-40 x 1/4 inch, BHP (not shown)
	385-0109-00	XB140000		2	ROD, plastic, 4-40 x 5/16 inch (not shown)
	210-0004-00	XB140000		2	LOCKWASHER, internal, #4 (not shown)
	210-0054-00	XB140000		2	LOCKWASHER, split, #4 (not shown)
	211-0008-00	XB140000		2	SCREW, 4-40 x 1/4 inch, PHS (not shown)
-70	670-0531-00			1	ASSEMBLY, circuit board—HORIZONTAL & AUDIO
	- - - - - -			-	assembly includes:
	388-0895-00			1	BOARD, circuit
-71	214-0506-00			23	PIN, connector
-72	214-0579-00			1	PIN, test point
-73	136-0220-00			19	SOCKET, transistor, 3 pin
-74	386-1251-00			1	CHASSIS, support
	- - - - - -			-	chassis includes:
-75	348-0123-00			1	PAD, cushioning
-76	214-0915-00	B010100	B139999X	1	GASKET, rear cabinet
-77	129-0128-00			2	POST, metal, 2.250 inches long
	- - - - - -			-	mounting hardware for each: (not included w/post)
-78	210-0006-00			1	LOCKWASHER, internal, #6
-79	134-0014-00			2	PLUG, banana, male
	- - - - - -			-	mounting hardware for each: (not included w/plug)
-80	210-0935-00			2	WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0802-00			1	WASHER, flat, 0.150 ID x 5/16 inch OD
	210-0202-00			1	LUG, solder, SE #6
-81	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-82	134-0014-00			1	PLUG, banana, male
	- - - - - -			-	mounting hardware: (not included w/plug)
-83	210-0935-00			2	WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0802-00			1	WASHER, flat, 0.150 ID x 5/16 inch OD
	210-0204-00			1	LUG, solder, SE #6
-84	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch

FIG. 1 RIGHT SIDE & CHASSIS *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-85	131-0509-00			1	CONNECTOR, 12 contact, male, w/mounting hardware
	- - - - - -			-	mounting hardware: (not included w/connector)
-86	131-0504-00			1	TERMINAL, lug
	210-1032-00			1	WASHER, fiber, 0.820 ID x 1.100 inch OD
-87	210-1031-00			1	WASHER, fiber, shouldered, 0.820 ID x 1.080 inch OD
-88	131-0508-00			1	CONNECTOR, 7 contact, male, w/mounting hardware
-89	131-0511-00			2	TERMINAL, feed thru
-90	179-1202-00	B010100	B109999	1	CABLE HARNESS, physiological monitor chassis
	179-1202-01	B110000		1	CABLE HARNESS, physiological monitor chassis
	- - - - - -			-	cable harness includes:
	131-0371-00	B010100	B109999	39	CONNECTOR, single contact
	131-0371-00	B110000		41	CONNECTOR, single contact

FIG. 2 016-0107-00

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
	016-0107-00			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
-1	202-0159-00			1	BASE
-2	131-0031-00			2	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
	210-1026-00			-	WASHER, lock, external, 0.250 inch diameter
-3	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-4	210-0269-00			2	LUG, terminal
-5	131-0031-00			2	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-6	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-7	210-0269-00			1	LUG, terminal
-8	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-9	211-0507-00			2	SCREW, 6-32 x 0.312 inch
-10	210-0202-00			1	LUG, solder, SE #6
-11	386-0143-00			1	PLATE, insulator
-12	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.140 ID x 0.281 inch OD
-13	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
	210-0006-00			2	WASHER, lock, internal, #6
-14	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, solder
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-15	211-0065-00			2	SCREW, 4-40 x 0.188 inch, PHS
-16	210-0406-00			2	NUT, hex., 4-40 x 0.188 inch
-17	441-0740-00			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-18	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-19	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-20	211-0131-00			1	SCREW, 4-40 x 1.875 inches
	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-21	211-0020-00			1	SCREW, 4-40 x 1.125 inches, RHS
-22	129-0129-00			2	POST, metallic, 1.125 inches, long
	210-0004-00			2	WASHER, lock, internal, #4

FIG. 2 016-0107-00 (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-23	670-0529-00			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	assembly includes:
	388-0893-00			1	CIRCUIT BOARD
-24	136-0220-00			1	SOCKET, transistor, 3 pin
-25	214-0506-00			7	PIN, connector
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-26	211-0116-00			4	SCREW, sems, 4-40 x 0.313 inch, PHB
-27	146-0011-00			10	BATTERY, dry, 1.25 V
-28	348-0119-00			10	PAD, cushioning
-29	348-0122-00			1	PAD, cushioning
-30	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-31	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-32	214-0927-00			1	RETAINER, reed switch
	- - - - - -			-	mounting hardware: *(not included w/retainer)*
-33	213-0113-00			2	SCREW, thread forming, 2-32 x 0.313 inch, PHS
-34	204-0301-00			1	BODY, connector
	- - - - - -			-	mounting hardware: *(not included w/body)*
-35	211-0097-00			2	SCREW, 4-40 x 0.313 inch, PHS
-36	210-0406-00			2	NUT, hex., 4-40 x 0.25 inch
-37	131-0371-00			6	CONNECTOR, single contact
-38	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-39	354-0311-00			1	RING, rubber
-40	200-0757-00			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-41	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
	211-0097-00			2	SCREW, 4-40 x 0.313 inch, PHS
-42	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 3 016-0107-02

MODEL 1 and 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
	016-0107-02			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
-1	202-0159-01			1	BASE, battery pack
-2	131-0031-00			1	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-3	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-4	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-5	210-0269-00			2	LUG, terminal
-6	131-0031-00			2	CONNECTOR, banana jack
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-7	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-8	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-9	210-0269-00			1	LUG, terminal
-10	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-11	210-0001-00			1	WASHER, lock, internal, #2
-12	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	386-0143-00			1	PLATE, insulator
-15	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.14 ID x 0.281 inch OD
-16	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	WASHER, lock, internal, #6
-17	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, solder
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-19	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-20	210-0406-00			2	NUT, hex., 4-40 x 0.187 inch
-21	252-0562-00			ft	STRIP, plastic, 1.5 inches
-22	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: *(not included w/lug)*
-23	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-24	441-0740-01			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-25	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
-26	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD

FIG. 3 016-0107-02 (cont)

MODEL 1 and 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-27	- - - - - -			-	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-28	211-0166-00			1	SCREW, 4-40 x 1.75 inches, PHS
-29	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-30	129-0251-00			1	POST, plastic, 1.125 inches long
-31	211-0019-00			1	SCREW, 4-40 x 1.0 inch, RHS
-32	210-0994-00			2	WASHER, flat, 0.125 ID x 0.25 inch OD
-33	210-0004-00			1	WASHER, lock, internal, #4
-34	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-35	670-0529-01			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	circuit board assembly includes:
	388-0893-01			1	CIRCUIT BOARD
-36	131-0608-00			10	PIN, connector, 0.365 inch long
-37	136-0252-01			1	SOCKET, pin connector, 0.178 inch long
-38	136-0350-00			9	SOCKET, transistor, 3 pin
-39	136-0337-00			1	SOCKET, relay, 8 pin
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-40	211-0168-00			4	SCREW, 4-40 x 0.25 inch, PHS
-41	210-1002-00			4	WASHER, flat, 0.125 ID x 0.25 inch OD
-42	146-0011-01			10	BATTERY, dry, 1.25 V, Ni Cd, solder lug type
-43	348-0119-00			10	PAD, cushioning, battery
-44	348-0122-00			1	PAD, cushioning, fuse
-45	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-46	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-47	343-0002-00			1	CLAMP, cable, 0.187 inch, plastic
	- - - - - -			-	mounting hardware: *(not included w/clamp)*
-48	213-0054-00			1	SCREW, thread forming, 6-32 x 0.312 inch
-49	210-0863-00			1	WASHER, "D" type
-50	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-51	210-0001-00			1	WASHER, lock, internal, #2
-52	210-0201-00			2	LUG, solder, SE #4
-53	131-0859-00			1	CONNECTOR, plug, electrical
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-54	213-0087-00			2	SCREW, thread forming, 2-32 x 0.50 inch
-55	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-56	354-0311-00			1	RING, rubber
-57	200-0757-01			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-58	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
-59	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 4 016-0107-02 (cont)

MODEL 1 and 2

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-60	179-1461-00			1	HARNESS, wiring, line
	179-1462-00			1	HARNESS, wiring, power
	- - - - - -			-	harness includes:
-61	131-0707-00			9	CONNECTOR, terminal
-62	352-0176-00			1	HOLDER, terminal connector, 4 wire
-63	352-0177-00			1	HOLDER, terminal connector, 6 wire

FIG. 4 016-0107-02

MODEL 3

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
	016-0107-02			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
-1	202-0159-00			1	BASE, battery pack
-2	131-0031-00			1	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-3	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-4	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-5	210-0269-00			2	LUG, terminal
-6	131-0031-00			2	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-7	210-1026-00			1	WASHER, lock, internal, 0.25 inch diameter
-8	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-9	210-0269-00			1	LUG, terminal
-10	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-11	210-0001-00			1	WASHER, lock, internal, #2
-12	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	386-0143-00			1	PLATE, insulator
-15	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.14 ID x 0.281 inch OD
-16	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	WASHER, lock, internal, #6
-17	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, solder
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-19	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-20	210-0406-00			2	NUT, hex., 4-40 x 0.187 inch
-21	252-0562-00			ft	STRIP, plastic, 1.5 inches
-22	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: *(not included w/lug)*
-23	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-24	441-0740-01			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-25	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
-26	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD

FIG. 4 016-0107-02 (cont)

MODEL 3

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
-27	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-28	211-0166-00			1	SCREW, 4-40 x 1.75 inches, PHS
-29	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-30	129-0251-00			1	POST, plastic, 1.125 inches long
-31	211-0019-00			1	SCREW, 4-40 x 1.0 inch, RHS
-32	210-0994-00			2	WASHER, flat, 0.125 ID x 0.25 inch OD
-33	210-0004-00			1	WASHER, lock, internal, #4
-34	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-35	670-0529-01			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	circuit board assembly includes:
	388-0893-01			1	CIRCUIT BOARD
-36	131-0608-00			10	PIN, connector, 0.365 inch long
-37	136-0252-01			1	SOCKET, pin connector, 0.178 inch long
-38	136-0337-00			1	SOCKET, relay, 8 pin
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-39	211-0168-00			4	SCREW, 4-40 x 0.25 inch, PHS
-40	210-1002-00			4	WASHER, flat, 0.125 ID x 0.25 inch OD
-41	146-0011-01			10	BATTERY, dry, 1.25 V, Ni Cd, solder lug type
-42	348-0119-00			10	PAD, cushioning, battery
-43	348-0122-00			1	PAD, cushioning, fuse
-44	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-45	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-46	343-0002-00			1	CLAMP, cable, 0.187 inch, plastic
	- - - - - -			-	mounting hardware: *(not included w/clamp)*
-47	213-0054-00			1	SCREW, thread forming, 6-32 x 0.312 inch
-48	210-0863-00			1	WASHER "D" type
-49	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*. .
-50	210-0001-00			1	WASHER, lock, internal, #2
-51	210-0201-00			2	LUG, solder, SE #4
-52	131-0859-00			1	CONNECTOR, plug, electrical, w/hardware
-53	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-54	354-0311-00			1	RING, rubber
-55	200-0757-01			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-56	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
-57	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 3 016-0107-02 (cont)

MODEL 3

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-58	179-1461-00			1	HARNESS, wiring, line
	179-1462-00			1	HARNESS, wiring, power
	- - - - - -			-	harness includes:
-59	131-0707-00			9	CONNECTOR, terminal
-60	352-0176-00			1	HOLDER, terminal connector, 4 wire
-61	352-0177-00			1	HOLDER, terminal connector, 6 wire

FIG. 4 016-0107-02 (cont)

MODEL 4

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
	016-0107-02			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
1	202-0159-01			1	BASE, battery pack
-2	131-0031-00			1	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-3	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-4	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-5	210-0269-00			2	LUG, terminal
-6	131-0031-00			2	CONNECTOR, banana jack female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-7	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-8	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-9	210-0269-00			1	LUG, terminal
-10	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-11	210-0001-00			1	WASHER, lock, internal, #2
-12	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	386-0143-00			1	PLATE, insulator
-15	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.14 x 0.281 inch OD
-16	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	WASHER, lock, internal, #6
-17	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, solder
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-19	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-20	210-0406-00			2	NUT, hex., 4-40 x 0.187 inch
-21	252-0562-00			ft	STRIP, plastic, 1.5 inches
-22	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: *(not included w/lug)*
-23	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-24	441-0740-01			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-25	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
-26	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD

FIG. 4 016-0107-02 (cont)

MODEL 4

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
-27	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-28	211-0166-00			1	SCREW, 4-40 x 1.75 inches, PHS
-29	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-30	129-0251-00			1	POST, plastic, 1.125 inches long
-31	211-0019-00			1	SCREW, 4-40 x 1.0 inches, RHS
-32	210-0994-00			2	WASHER, flat, 0.125 ID x 0.25 inch OD
-33	210-0004-00			1	WASHER, lock, internal, #4
-34	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-35	670-0529-02			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	circuit board assembly includes:
	388-0893-02			1	CIRCUIT BOARD
-36	131-0608-00			10	PIN, connector, 0.365 inch long
-37	136-0252-01			1	SOCKET, pin connector, 0.178 inch long
-38	136-0337-00			1	SOCKET, relay, 8 pin
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-39	211-0168-00			4	SCREW, 4-40 x 0.25 inch, PHS
-40	210-1002-00			4	WASHER, flat, 0.125 ID x 0.25 inch OD
	210-0823-00			4	WASHER, fiber, 0.125 ID x 0.25 inch OD
-41	146-0011-01			10	BATTERY, dry, 1.25 V, Ni Cd, solder lug type
-42	348-0119-00			10	PAD, cushioning, battery
-43	348-0122-00			1	PAD, cushioning, fuse
-44	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-45	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-46	343-0002-00			1	CLAMP, cable, 0.187 inch, plastic
	- - - - - -			-	mounting hardware: *(not included w/clamp)*
-47	213-0054-00			1	SCREW, thread forming, 6-32 x 0.312 inch
-48	210-0863-00			1	WASHER, "D" type
-49	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-50	210-0001-00			1	WASHER, lock, internal, #2
-51	210-0201-00			2	LUG, soldering, SE #4
-52	131-0859-00			1	CONNECTOR, plug, electrical, w/hardware
-53	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-54	354-0311-00			1	RING, rubber
-55	200-0757-01			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-56	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
-57	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 4 016-0107-02 (cont)

MODEL 4

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-58	179-1461-00			1	HARNESS, wiring, line
	179-1462-00			1	HARNESS, wiring, power
	- - - - - -			-	harness includes:
-59	131-0707-00			9	CONNECTOR, terminal
-60	352-0176-00			1	HOLDER, terminal, connector, 4 wire
-61	352-0177-00			1	HOLDER, terminal, connector, 6 wire

FIG. 4 016-0107-02 (cont)

MODEL 5

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
	016-0107-02			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
-1	202-0159-01			1	BASE, battery pack
-2	131-0031-00			1	CONNECTOR, banana jack female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-3	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-4	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-5	210-0269-00			2	LUG, terminal
-6	131-0031-00			2	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-7	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-8	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-9	210-0269-00			1	LUG, terminal
-10	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-11	210-0001-00			1	WASHER, lock, internal, #2
-12	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	386-0143-00			1	PLATE, insulator
-15	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.14 ID x 0.281 inch OD
-16	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	WASHER, lock, internal, #6
-17	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, soldering
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-19	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-20	210-0406-00			2	NUT, hex., 4-40 x 0.187 inch
-21	252-0562-00			ft	STRIP, plastic, 1.5 inches
-22	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: *(not included w/lug)*
-23	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-24	441-0740-01			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-25	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
-26	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD

FIG. 4 016-0107-02 (cont)

MODEL 5

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-27	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-28	211-0166-00			1	SCREW, 4-40 x 1.75 inches, PHS
-29	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-30	129-0251-00			1	POST, plastic, 1.125 inches long
-31	211-0019-00			1	SCREW, 4-40 x 1.0 inch, RHS
-32	210-0994-00			2	WASHER, flat, 0.125 ID x 0.25 inch OD
-33	210-0004-00			1	WASHER, lock, internal, #4
-34	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-35	670-0529-02			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	circuit board assembly includes:
	388-0893-02			1	CIRCUIT BOARD
-36	131-0608-00			10	PIN, connector, 0.365 inch long
-37	136-0252-01			1	SOCKET, pin connector, 0.178 inch long
-38	136-0337-00			1	SOCKET, relay, 8 pin
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-39	211-0168-00			4	SCREW, 4-40 x 0.25 inch, PHS
-40	210-1002-00			4	WASHER, flat, 0.125 ID x 0.25 inch OD
	210-0823-00			4	WASHER, fiber, 0.125 ID x 0.25 inch OD
-41	146-0011-01			10	BATTERY, dry, 1.25 V, Ni Cd, solder lug type
-42	348-0119-00			10	PAD, cushioning, battery
-43	348-0122-00			1	PAD, cushioning, fuse
-44	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-45	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-46	343-0002-00			1	CLAMP, cable, 0.187 inch, plastic
	- - - - - -			-	mounting hardware: *(not included w/clamp)*
-47	213-0054-00			1	SCREW, thread forming, 6-32 x 0.312 inch
-48	210-0863-00			1	WASHER, "D" type
-49	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-50	210-0001-00			1	WASHER, lock, internal, #2
-51	210-0201-00			2	LUG, solder, SE #4
-52	131-0859-00			1	CONNECTOR, plug, electrical, w/hardware
-53	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-54	354-0311-00			1	RING, rubber
-55	200-0757-01			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-56	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
-57	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 4 016-0107-02 (cont)

MODEL 5

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-58	179-1461-00			1	HARNESS, wiring, line
	179-1462-00			1	HARNESS, wiring, power
	- - - - - -			-	harness includes:
-59	131-0707-00			9	CONNECTOR, terminal
-60	352-0176-00			1	HOLDER, terminal connector, 4 wire
-61	352-0177-00			1	HOLDER, terminal connector, 6 wire

FIG. 4 016-0107-02 (cont)

MODEL 6

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
	016-0107-02			1	BATTERY PACK, 410
	- - - - - -			-	battery pack includes:
-1	202-0159-01			1	BASE, battery pack
-2	131-0031-00			1	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware: *(not included w/connector)*
-3	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-4	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-5	210-0269-00			2	LUG, terminal
-6	131-0031-00			2	CONNECTOR, banana jack, female
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-7	210-1026-00			1	WASHER, lock, external, 0.25 inch diameter
-8	210-0455-00			2	NUT, hex., 0.25-28 x 0.375 inch
-9	210-0269-00			1	LUG, terminal
-10	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-11	210-0001-00			1	WASHER, lock, internal, #2
-12	- - - - - -			1	TRANSISTOR
	- - - - - -			-	mounting hardware: *(not included w/transistor)*
-13	211-0507-00			2	SCREW, 6-32 x 0.312 inch, PHS
-14	386-0143-00			1	PLATE, insulator
-15	210-0811-00			2	WASHER, fiber, shouldered, #6
	210-0801-00			2	WASHER, flat, 0.14 ID x 0.281 inch OD
-16	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			1	WASHER, lock, internal, #6
-17	210-0407-00			2	NUT, hex., 6-32 x 0.25 inch
-18	260-0675-01			1	SWITCH, slide
	- - - - - -			-	switch includes:
	337-1036-00			1	SHIELD, solder
	- - - - - -			-	mounting hardware: *(not included w/switch)*
-19	211-0007-00			2	SCREW, 4-40 x 0.187 inch, PHS
-20	210-0406-00			2	NUT, hex., 4-40 x 0.187 inch
-21	252-0562-00			ft	STRIP, plastic, 1.5 inches
-22	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: *(not included w/lug)*
-23	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-24	441-0740-01			1	CHASSIS
	- - - - - -			-	mounting hardware: *(not included w/chassis)*
-25	211-0018-00			1	SCREW, 4-40 x 0.875 inch, RHS
-26	210-0994-00			1	WASHER, flat, 0.125 ID x 0.250 inch OD

FIG. 4 016-0107-02 (cont)

MODEL 6

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
-27	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: *(not included w/transformer)*
-28	211-0166-00			1	SCREW, 4-40 x 1.75 inches, PHS
-29	210-0994-00			1	WASHER, flat, 0.125 ID x 0.25 inch OD
-30	129-0251-00			1	POST, plastic, 1.125 inches long
-31	211-0019-00			1	SCREW, 4-40 x 1.0 inch, RHS
-32	210-0994-00			2	WASHER, flat, 0.125 ID x 0.25 inch OD
-33	210-0004-00			1	WASHER, lock, internal, #4
-34	210-0406-00			1	NUT, hex., 4-40 x 0.25 inch
-35	670-0529-03			1	CIRCUIT BOARD ASSEMBLY—CHARGER
	- - - - - -			-	circuit board assembly includes:
	388-0893-03			1	CIRCUIT BOARD
-36	131-0608-00			10	PIN, connector, 0.365 inch long
-37	136-0252-01			1	SOCKET, pin connector, 0.178 inch long
-38	136-0337-00			1	SOCKET, relay, 8 pin
	- - - - - -			-	mounting hardware: *(not included w/circuit board assembly)*
-39	211-0168-00			4	SCREW, 4-40 x 0.25 inch, PHS
-40	210-1002-00			4	WASHER, flat, 0.125 ID x 0.25 inch OD
-41	146-0011-01			10	BATTERY, dry, 1.25 V, Ni Cd, solder lug type
-42	348-0119-00			10	PAD, cushioning, battery
-43	348-0122-00			1	PAD, cushioning, fuse
-44	386-1281-00			1	PLATE, fuse retaining
	- - - - - -			1	mounting hardware: *(not included w/plate)*
-45	213-0088-00			2	SCREW, thread forming, 4-40 x 0.25 inch, PHS
-46	343-0002-00			1	CLAMP, cable, 0.187 inch, plastic
	- - - - - -			-	mounting hardware: *(not included w/clamp)*
-47	213-0054-00			1	SCREW, thread forming, 6-32 x 0.312 inch
-48	210-0863-00			1	WASHER, "D" type
-49	131-0373-00			2	CONNECTOR, standoff
	- - - - - -			-	mounting hardware for each: *(not included w/connector)*
-50	210-0001-00			1	WASHER, lock, internal, #2
-51	210-0201-00			2	LUG, solder, SE #2
-52	131-0859-00			1	CONNECTOR, plug, electrical, w/hardware
-53	213-0131-00			2	SCREW, captive, 6-32 x 0.85 inch long
	- - - - - -			-	mounting hardware for each: *(not included w/screw)*
-54	354-0311-00			1	RING, rubber
-55	200-0757-01			1	COVER, battery pack
	- - - - - -			-	mounting hardware: *(not included w/cover)*
-56	211-0607-00			6	SCREW, 6-32 x 2.625 inches, PHS
-57	210-0407-00			6	NUT, hex., 6-32 x 0.25 inch

FIG. 4 016-0107-02 (cont)

MODEL 6

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
-58	179-1461-00			1	HARNESS, wiring, line
	179-1462-00			1	HARNESS, wiring, power
	- - - - - -			-	harness includes:
-59	131-0707-00			9	CONNECTOR, terminal
-60	352-0176-00			1	HOLDER, terminal connector, 4 wire
-61	352-0177-00			1	HOLDER, terminal connector, 6 wire

FIG. 5 CRT, CABINET & HANDLE ASSEMBLY

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
5-1	386-1322-00			1	PANEL ASSEMBLY, front
	- - - - - -			-	panel assembly includes:
-2	361-0172-00			4	CORNER, spacing
	- - - - - -			-	mounting hardware: *(not included w/panel assembly)*
	211-0511-00			2	SCREW, 6-32 x 1/2 inch, PHS *(not shown)*
-3	331-0186-00			1	GRATICULE, CRT
-4	343-0139-00	B010100	B049999	1	RETAINER, CRT
	343-0139-01	B050000		1	RETAINER, CRT
	214-0931-00	XB030000	B049999X	1	RETAINER, component *(not shown)*
	354-0306-00			1	RING, CRT shockmount
-6	337-0942-01			1	SHIELD, CRT
	- - - - - -			-	mounting hardware: *(not included w/shield)*
-7	384-0519-00			4	ROD, spacing
-8	348-0067-00			2	GROMMET, plastic, 5/16 inch diameter
-9	354-0305-00			1	RING, yoke support
-10	195-0046-00			1	LEAD, electrical
	- - - - - -			-	lead includes:
	131-0383-00			1	CONNECTOR, anode
	136-0268-00			1	ASSEMBLY, CRT socket
	- - - - - -			-	assembly includes:
-11	136-0253-02			1	SOCKET HALF, CRT rear
-12	136-0253-01			1	SOCKET HALF, CRT front
-13	131-0506-00			5	CONTACT, electrical
	131-0371-00			5	CONNECTOR, single contact *(not shown)*
	437-0093-00	B010100	B039999	1	ASSEMBLY, cabinet
	437-0093-01	B040000	B159999	1	ASSEMBLY, cabinet
	437-0093-02	B160000		1	ASSEMBLY, cabinet
	- - - - - -			-	assembly includes:
	367-0079-00			1	ASSEMBLY, carrying handle
	- - - - - -			-	assembly includes:
-14	334-1113-00			1	PLATE, identification
-15	200-0760-00			1	COVER, handle
-16	367-0077-00			1	HANDLE, carrying
	- - - - - -			-	mounting hardware: *(not included w/handle)*
-17	213-0180-00			1	SCREW, cap, 1/4-20 x 6 inches, Button Head Socket
-18	200-0758-01	B010100	B159999	1	CAP, handle end
	200-0758-03	B160000		1	CAP, handle end
-19	426-0369-01	B010100	B159999	1	FRAME, handle
	426-0369-03	B160000		1	FRAME, handle
-20	124-0203-00			1	STRIP, trim, inner
-21	384-0673-01			1	ROD, handle release, w/knob
-22	210-1029-00			1	WASHER, flat, 0.170 wide x 0.240 inch long
-23	214-0921-00			1	SPRING, compression
-24	210-1040-00			1	WASHER, flat, plastic, 0.170 wide x 0.240 inch long
-25	214-0916-00			1	KEY, gear locking
-26	214-0912-00			1	GEAR, spur

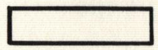
FIG. 5 CRT, CABINET & HANDLE ASSEMBLY (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
5-27	214-0937-00			1	SHIM, 1.006 x 1.185 inch OD
-28	386-1249-00			1	PLATE, retaining
	- - - - - -			-	mounting hardware: *(not included w/plate)*
-29	211-0101-00			3	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
	- - - - - -			-	mounting hardware: *(not included w/assembly)*
-30	212-0089-00			2	SCREW, cap, 8-32 x 0.625 inch, Socket HS
-31	210-1034-00			1	WASHER, spring tension, 1.051 ID x 1.351 inch OD
-32	124-0202-00			1	STRIP, trim, outer
-33	334-1114-00			1	PLATE, identification
-34	390-0009-01			2	CABINET, top-bottom
	- - - - - -			-	mounting hardware for each: *(not included w/cabinet)*
-35	211-0511-00			6	SCREW, 6-32 x 1/2 inch, PHS
-36	386-1248-01	B010100	B039999	1	SUBPANEL, left side
	386-1248-06	B040000		1	SUBPANEL, left side
	- - - - - -			-	subpanel includes:
-37	348-0114-00	B010100	B039999	1	FOOT, cabinet, rubber
	354-0326-00	B040000		1	FOOT, cabinet, rubber
-38	214-0914-00	B010100	B020165X	2	GASKET, cabinet side
-39	386-1277-00			1	PANEL, side
	- - - - - -			-	mounting hardware: *(not included w/panel)*
-40	213-0055-00			4	SCREW, thread forming, 2-32 x 3/16 inch, PHS
-41	331-0187-00			1	WINDOW, front panel
-42	214-0913-00			1	GASKET, front cabinet
-43	200-0759-00	B010100	B099999	1	COVER, rear
	200-0759-01	B100000		1	COVER, rear
	- - - - - -			-	cover includes:
	348-0090-00			2	CUSHION, 5/16 sponge
-44	252-0564-00			FT	PLASTIC, extruded channel *(7.250 inches)*

SECTION 9
DIAGRAMS

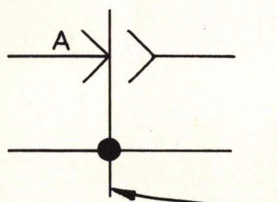
The following symbols are used on the diagrams:


Screwdriver adjustment


Front, side, or rear-panel control on connector

Clockwise control rotation in direction of arrow

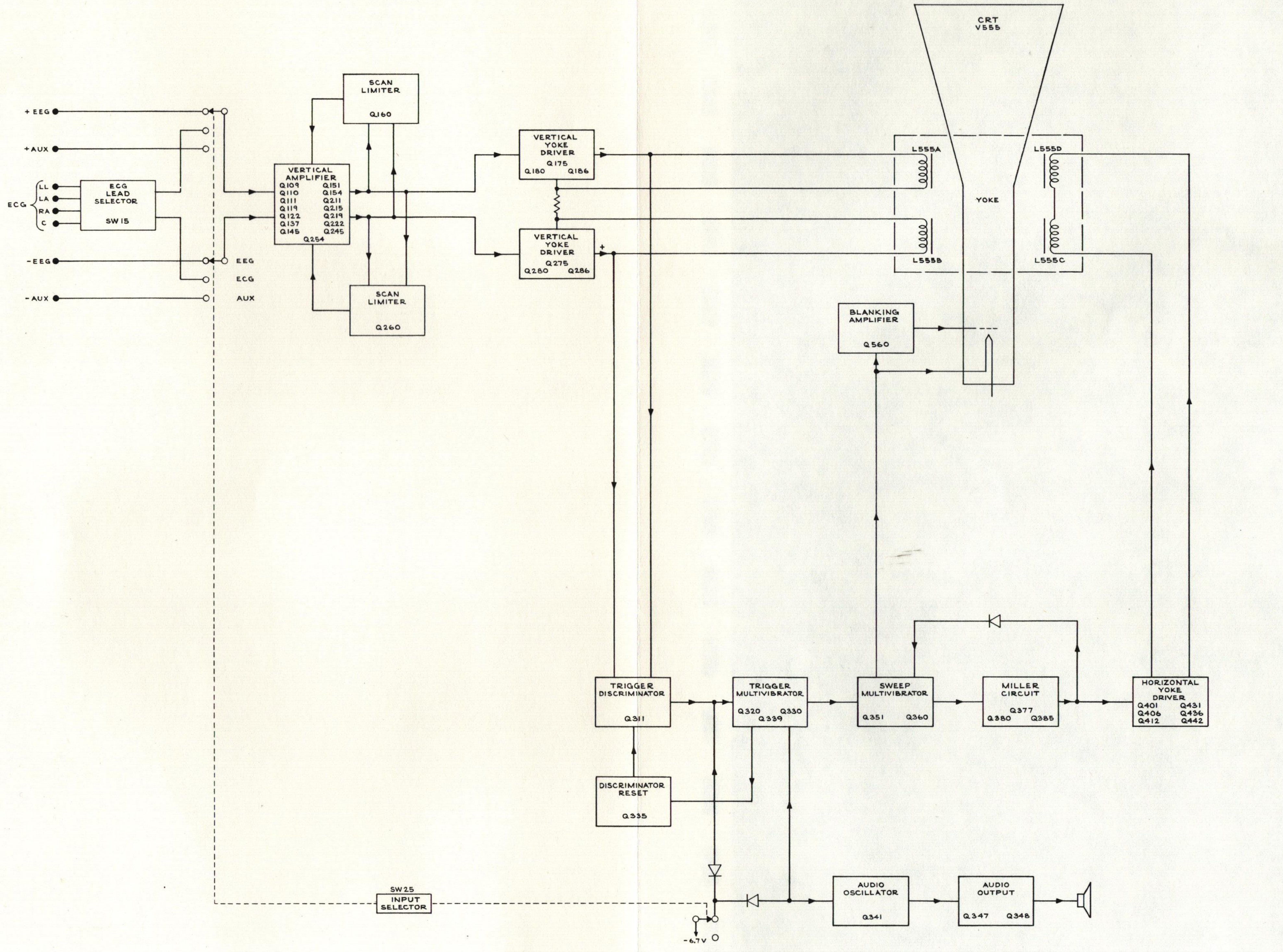
Refer to indicated diagram



Connection to circuit board made with pin connector at indicated pin

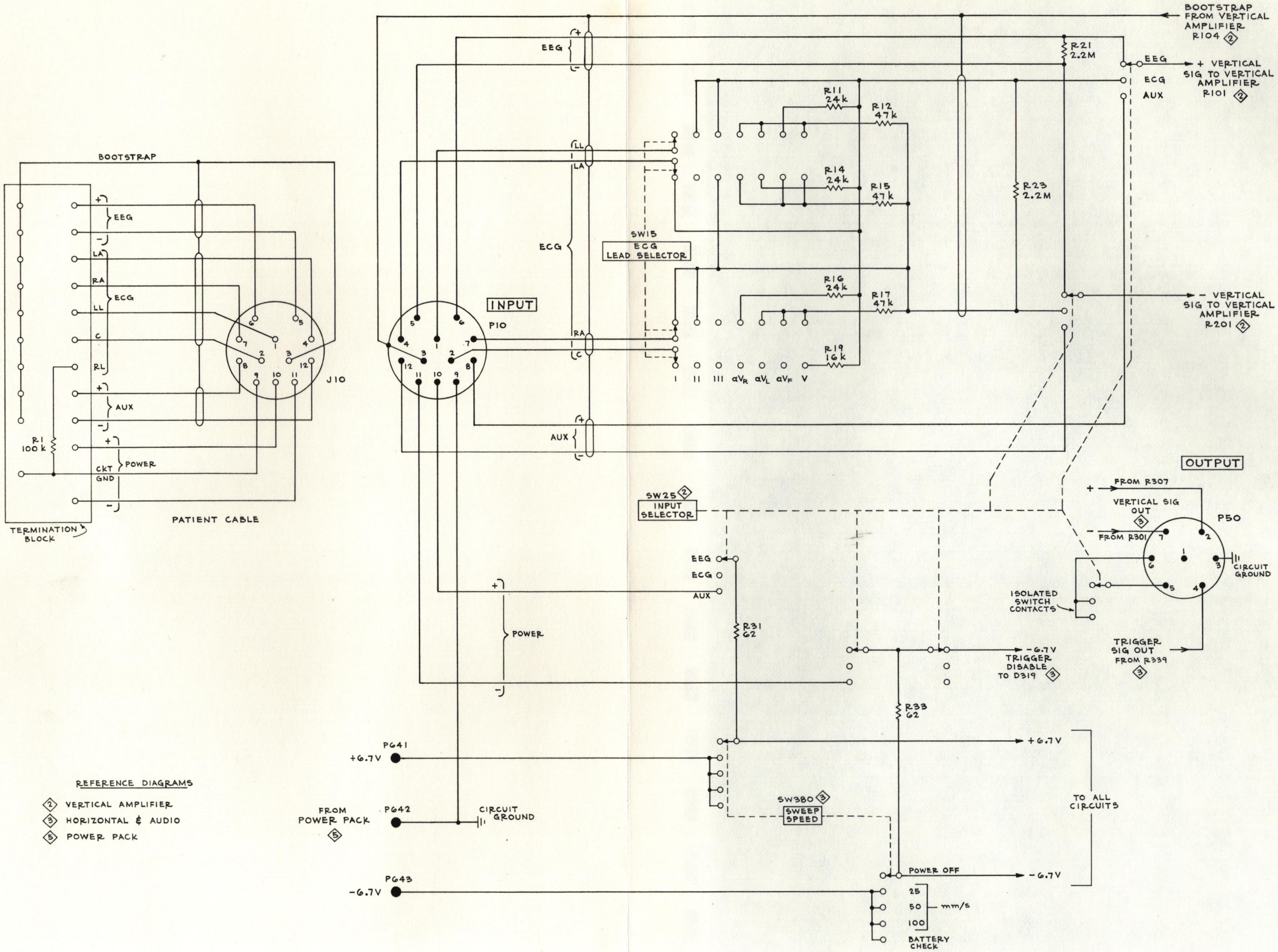
Connection soldered to circuit board

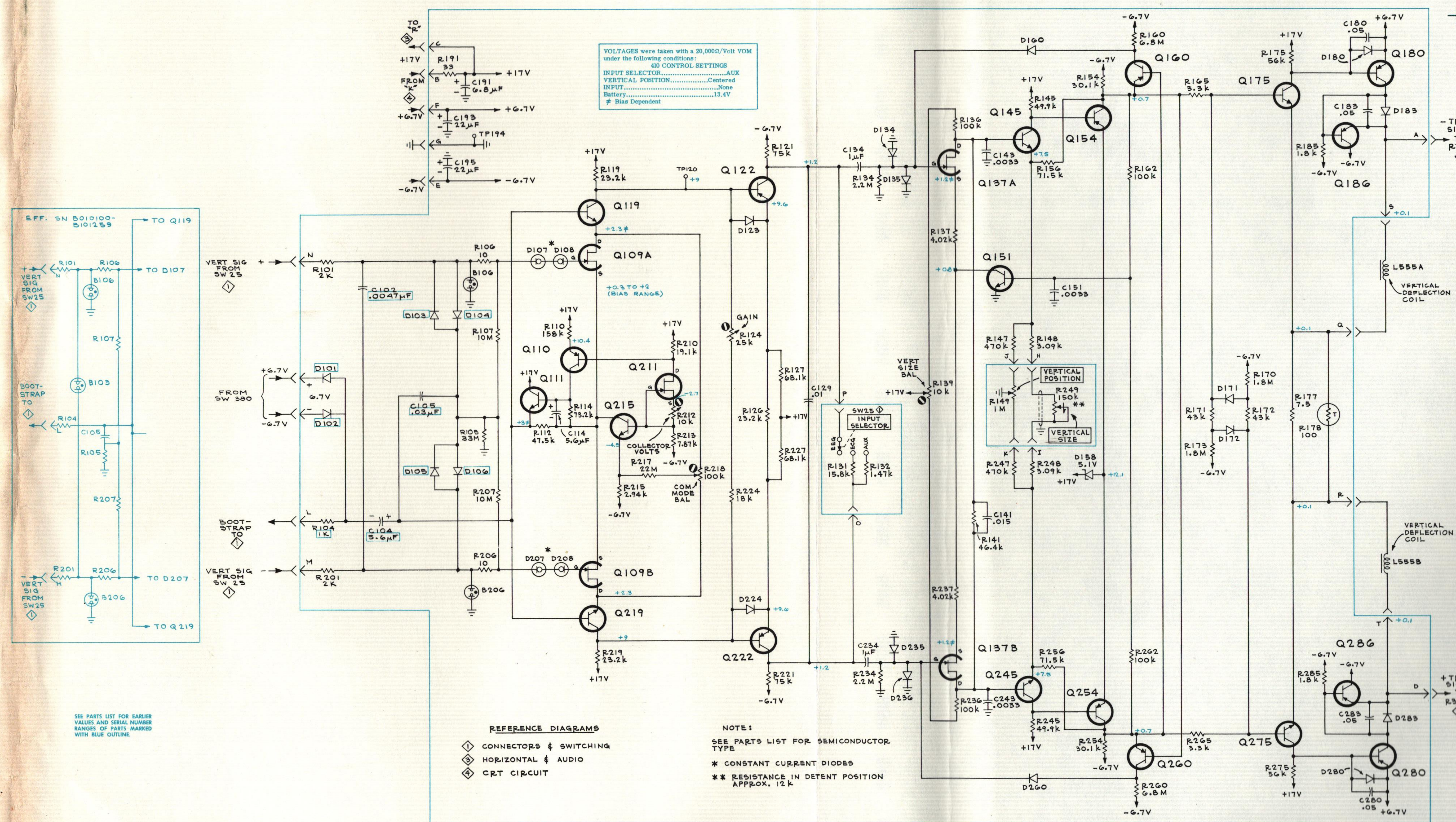
Blue line encloses components located on circuit board



TYPE 410 PHYSIOLOGICAL MONITOR

BLOCK DIAGRAM

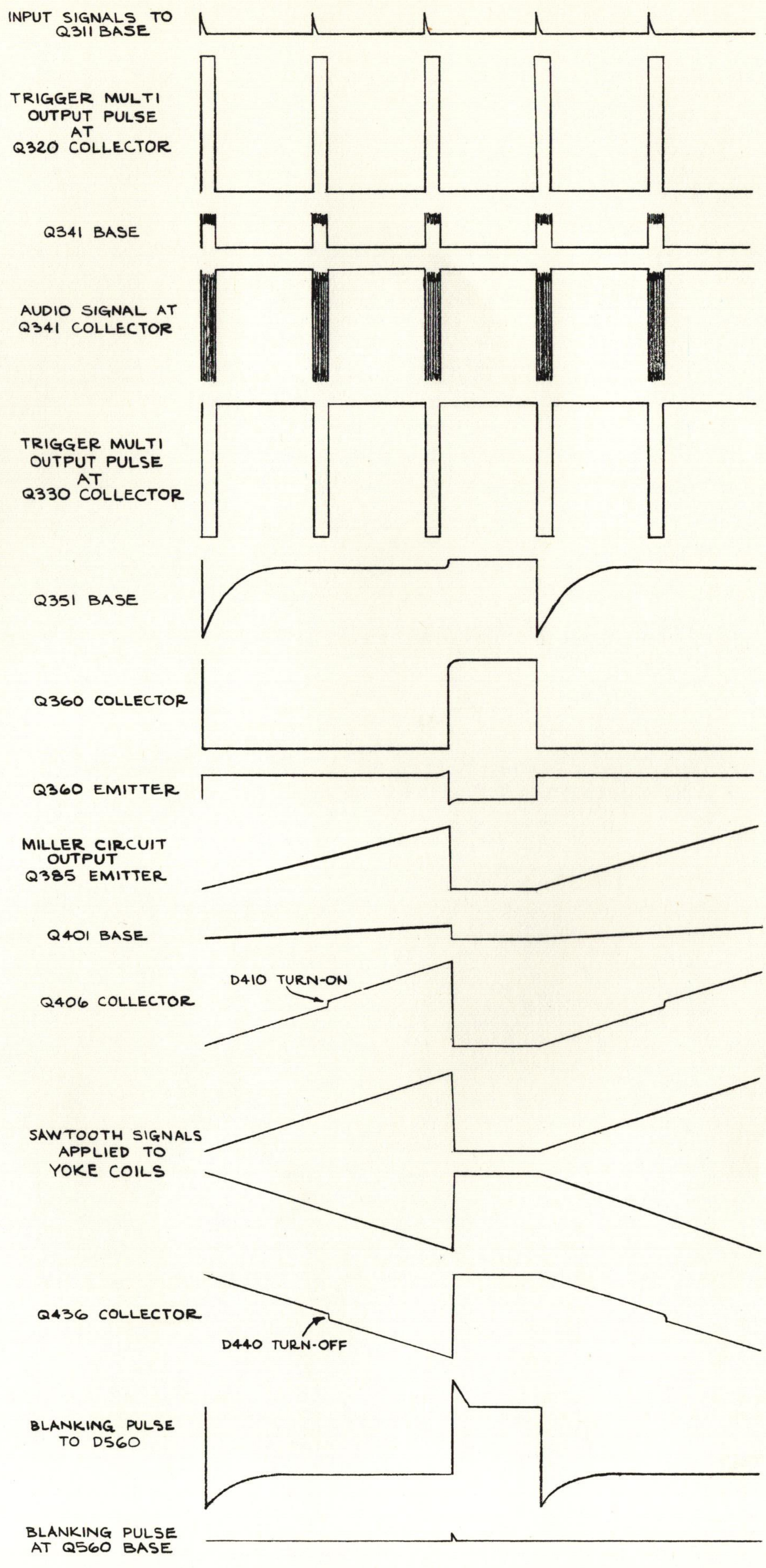

BOOTSTRAP
EEG
ECG
AUX
POWER
LA
RA
LL
C
RL
CKT GND
R1 100 k
TERMINATION BLOCK
PATIENT CABLE
J10
INPUT
P10
SW15 ECG LEAD SELECTOR
R11 24k
R12 47k
R14 24k
R15 47k
R16 24k
R17 47k
R19 16k
R21 2.2M
R23 2.2M
BOOTSTRAP FROM VERTICAL AMPLIFIER R104 2
+ VERTICAL SIG TO VERTICAL AMPLIFIER R101 2
- VERTICAL SIG TO VERTICAL AMPLIFIER R201 2
OUTPUT
P50
FROM R307
VERTICAL SIG OUT 3
FROM R301
CIRCUIT GROUND
ISOLATED SWITCH CONTACTS
TRIGGER SIG OUT FROM R339 3
SW25 2 INPUT SELECTOR
R31 62
R33 62
-6.7V TRIGGER DISABLE TO D319 3
P641
+6.7V
P642
FROM POWER PACK 5
CIRCUIT GROUND
P643
-6.7V
+6.7V
TO ALL CIRCUITS
SW380 3 SWEEP SPEED
POWER OFF
25
50
100
mm/s
BATTERY CHECK
REFERENCE DIAGRAMS
2 VERTICAL AMPLIFIER
3 HORIZONTAL & AUDIO
5 POWER PACK



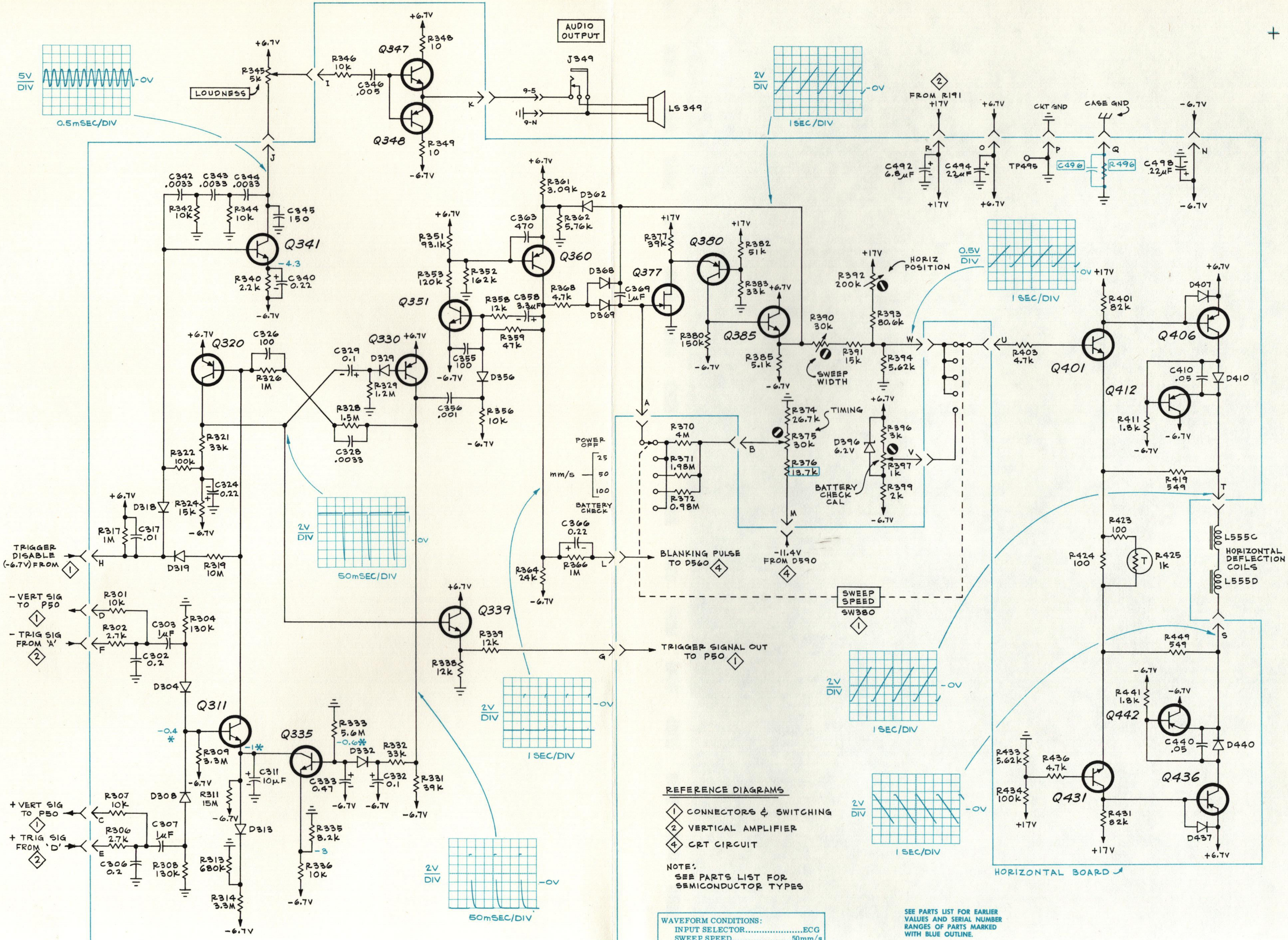
TYPE 410 PHYSIOLOGICAL MONITOR

VERTICAL AMPLIFIER 2

VERTICAL AMPLIFIER 2



HORIZONTAL & AUDIO CKT 3



REFERENCE DIAGRAMS

1 CONNECTORS & SWITCHING
2 VERTICAL AMPLIFIER
4 CRT CIRCUIT

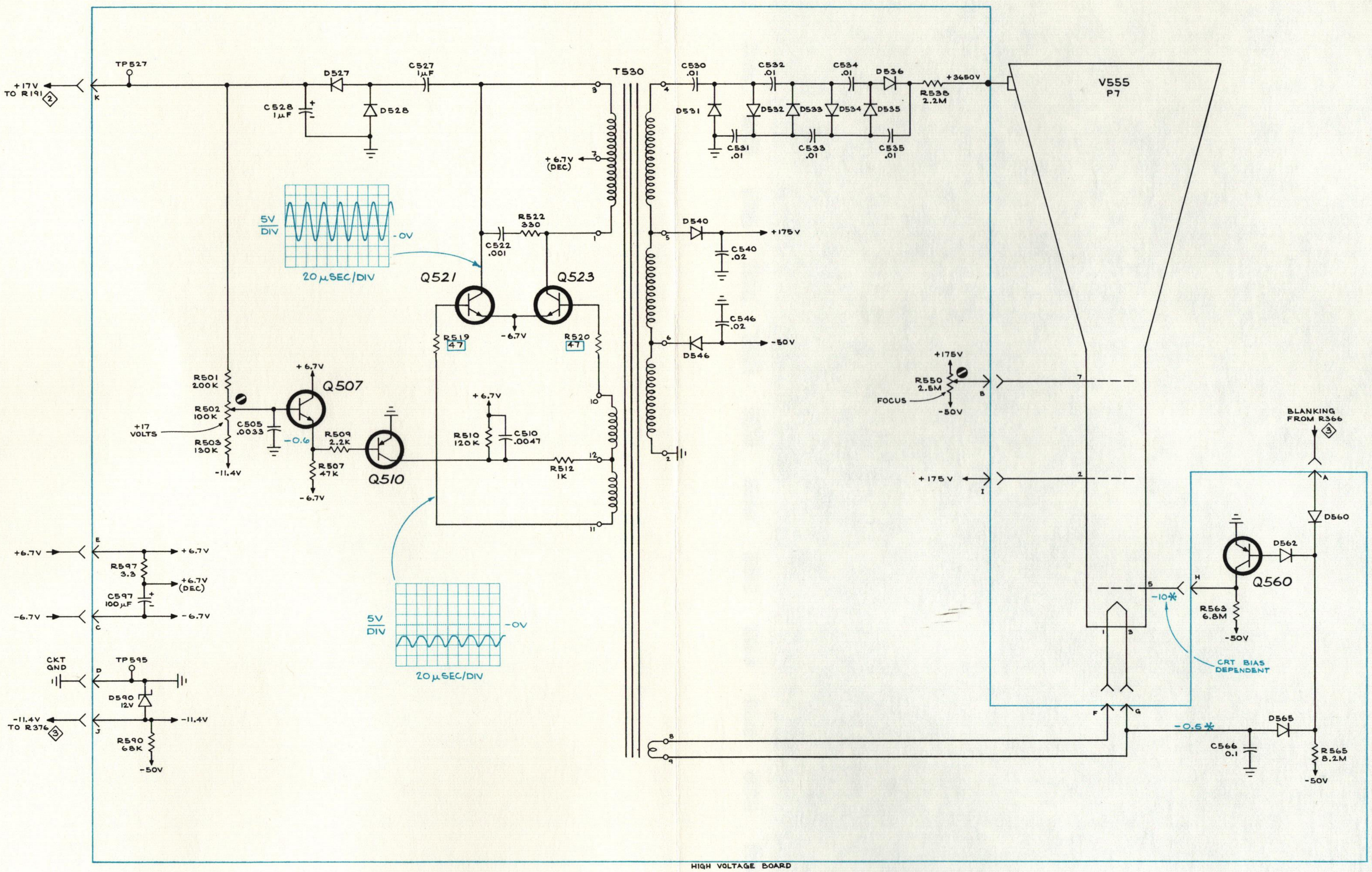
NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

WAVEFORM CONDITIONS:
INPUT SELECTOR....................ECG
SWEEP SPEED....................50mm/s
VERTICAL SIZE........................CCW
VERTICAL POSITION............Centered
*VOLTAGES were calculated

HORIZONTAL & AUDIO CIRCUIT 3

GAB 0170



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

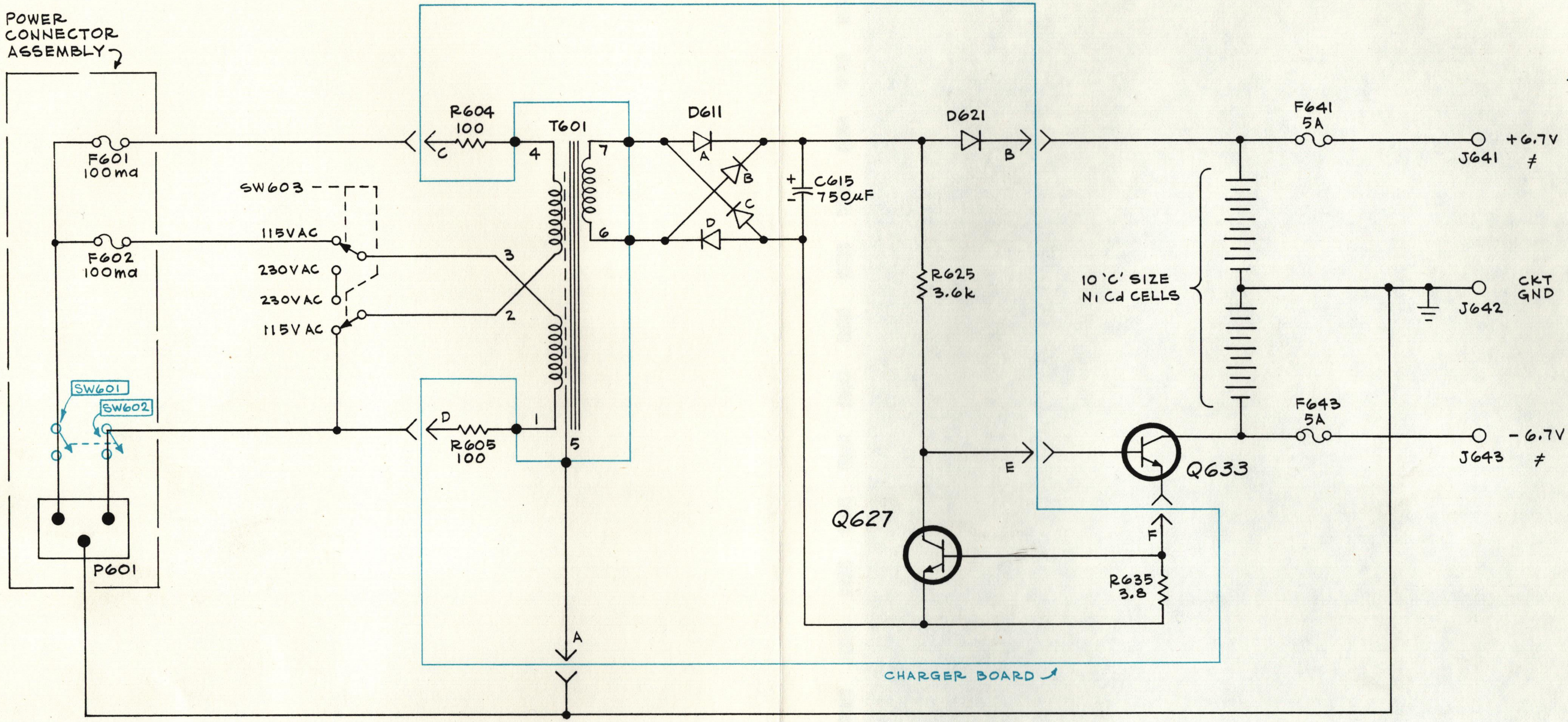
REFERENCE DIAGRAMS

② VERTICAL AMPLIFIER

③ HORIZONTAL & AUDIO CIRCUIT

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES were taken with a 20,000Ω/Volt VOM.
WAVEFORMS are not affected by Control Settings.
*Denotes calculated voltage.



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

≠ VOLTAGE VARIES WITH BATTERY CHARGE

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

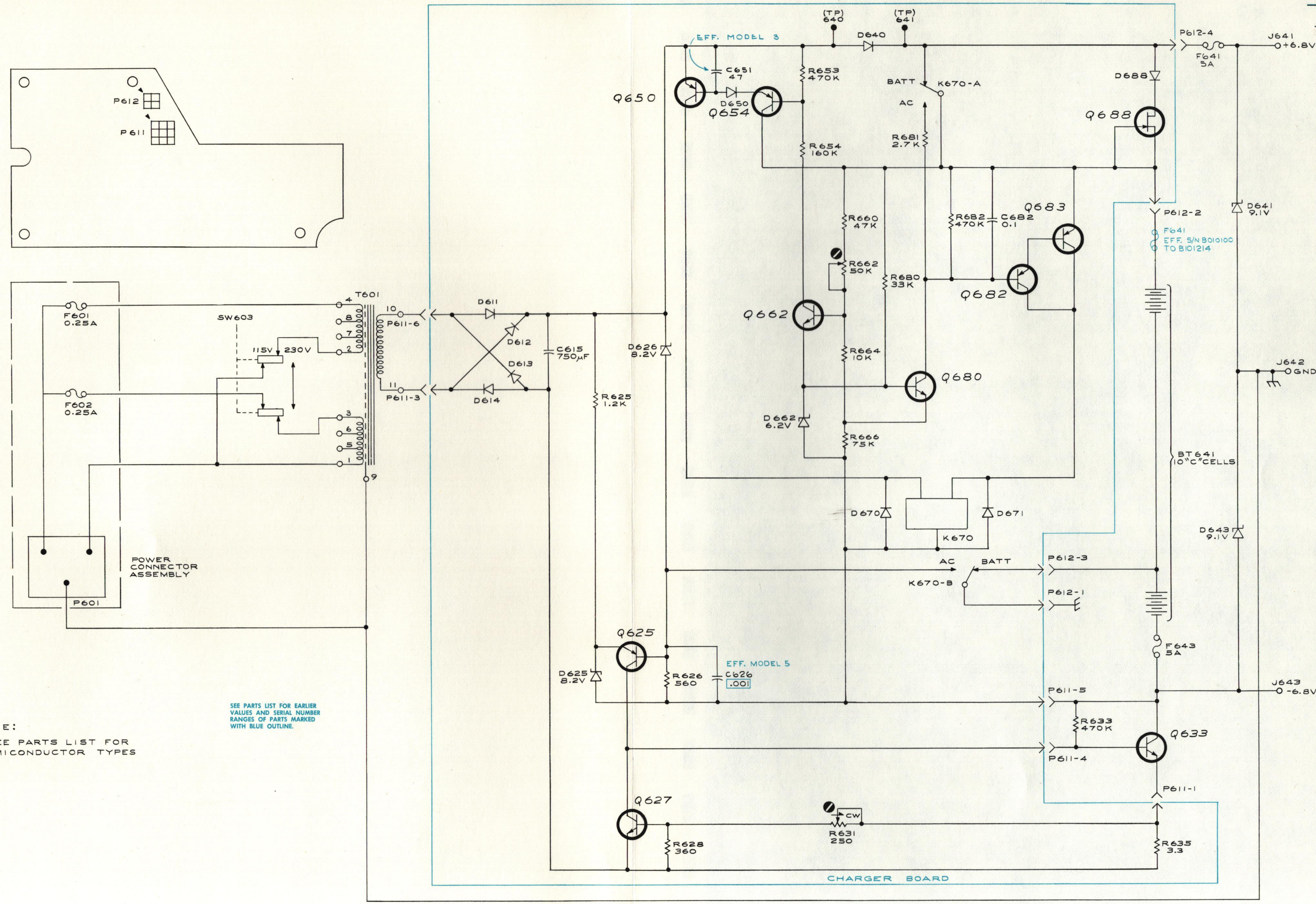
GAB
0170

TYPE 410 PHYSIOLOGICAL MONITOR

C1

POWER PACK (5)

MODELS 1 & 2
016-0107-00



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

NOTE:

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

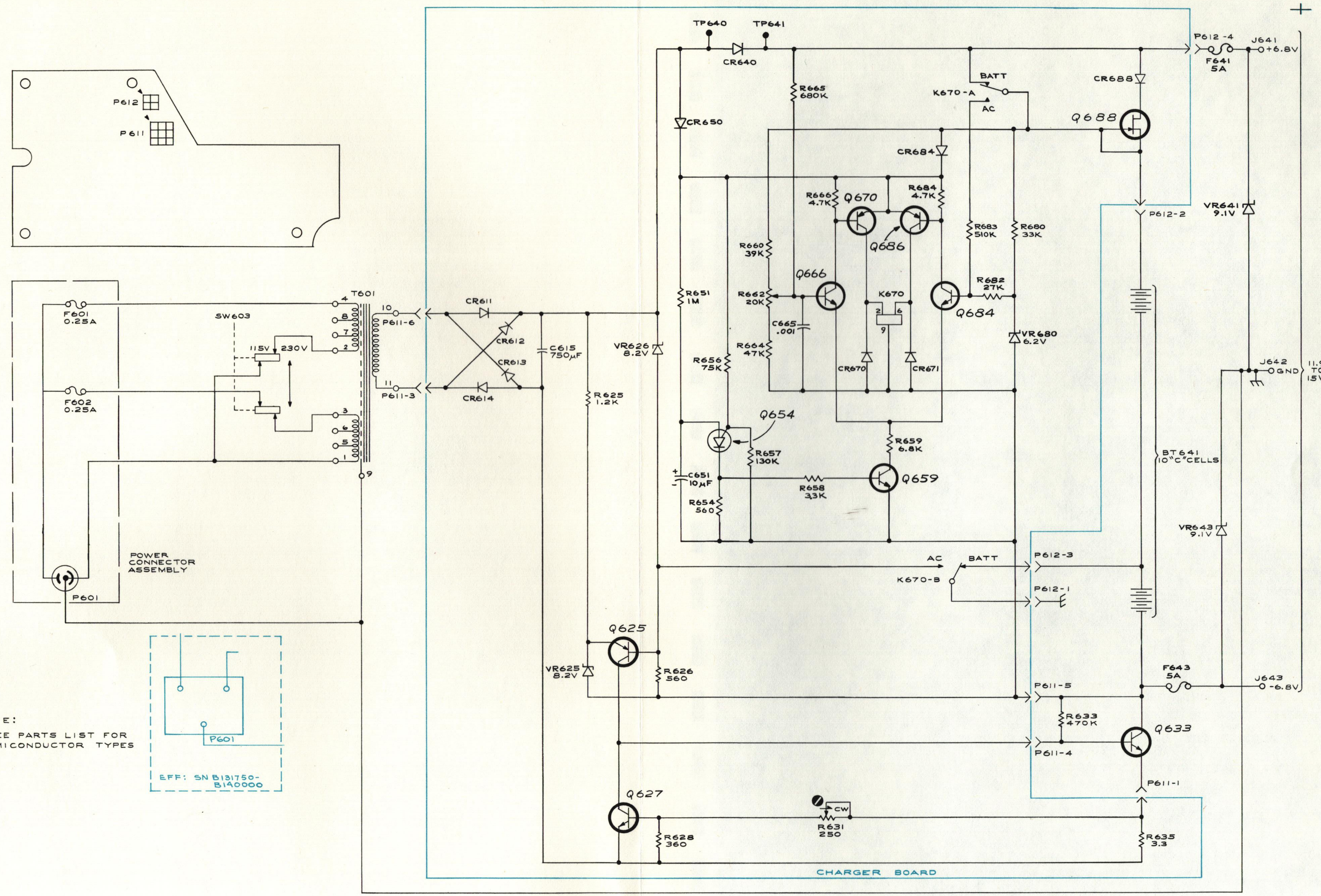
TYPE 410

POWER PACK (5)

MODELS 1,2,3

016-0107-02

VRS 0870



NOTE:
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE 410

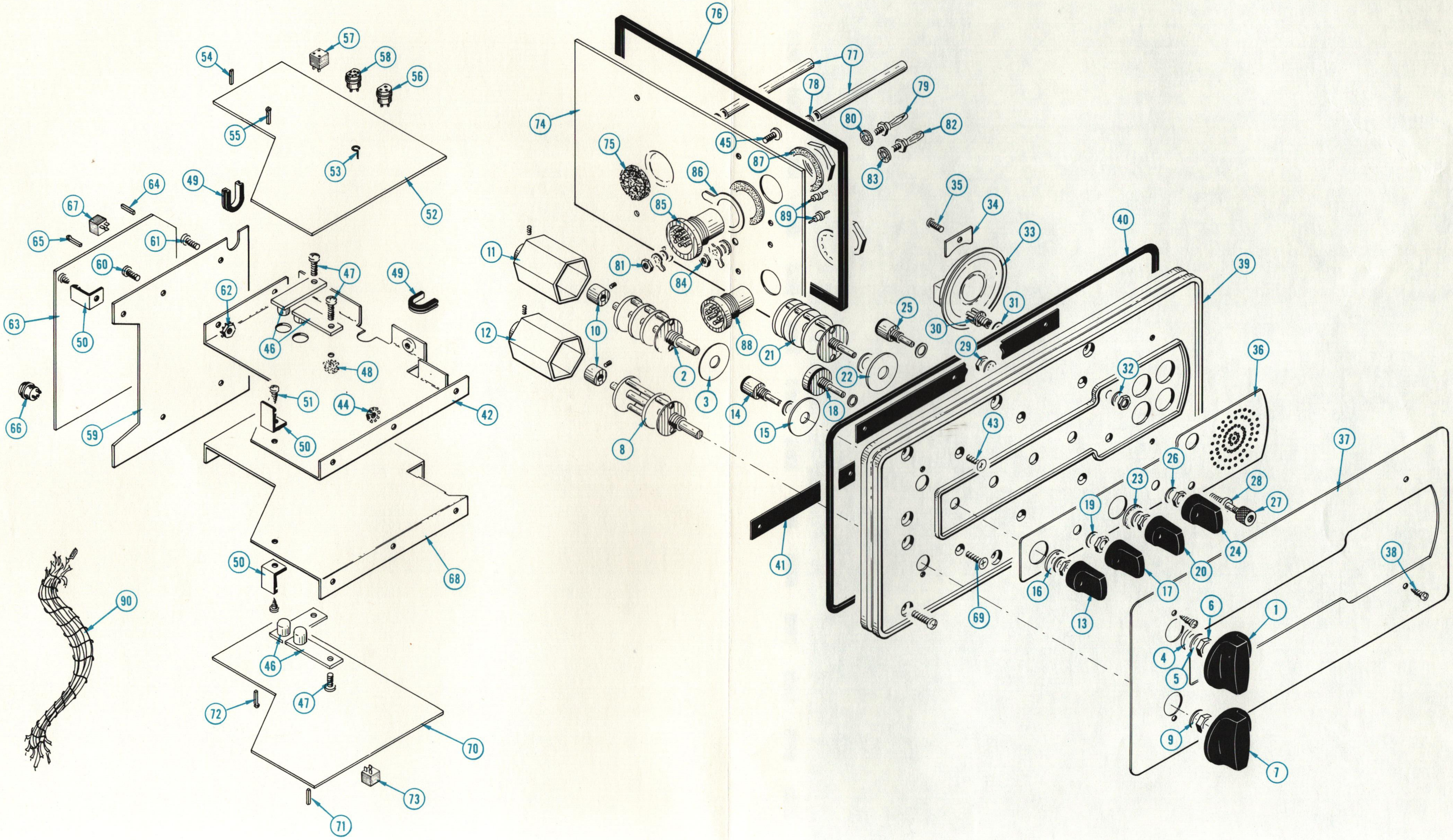
B

POWER PACK 5
MODELS 4-UP
016-0107-02

VRS 1170

POWER PACK 5

FIG. 1 RIGHT SIDE & CHASSIS



016-0107-00

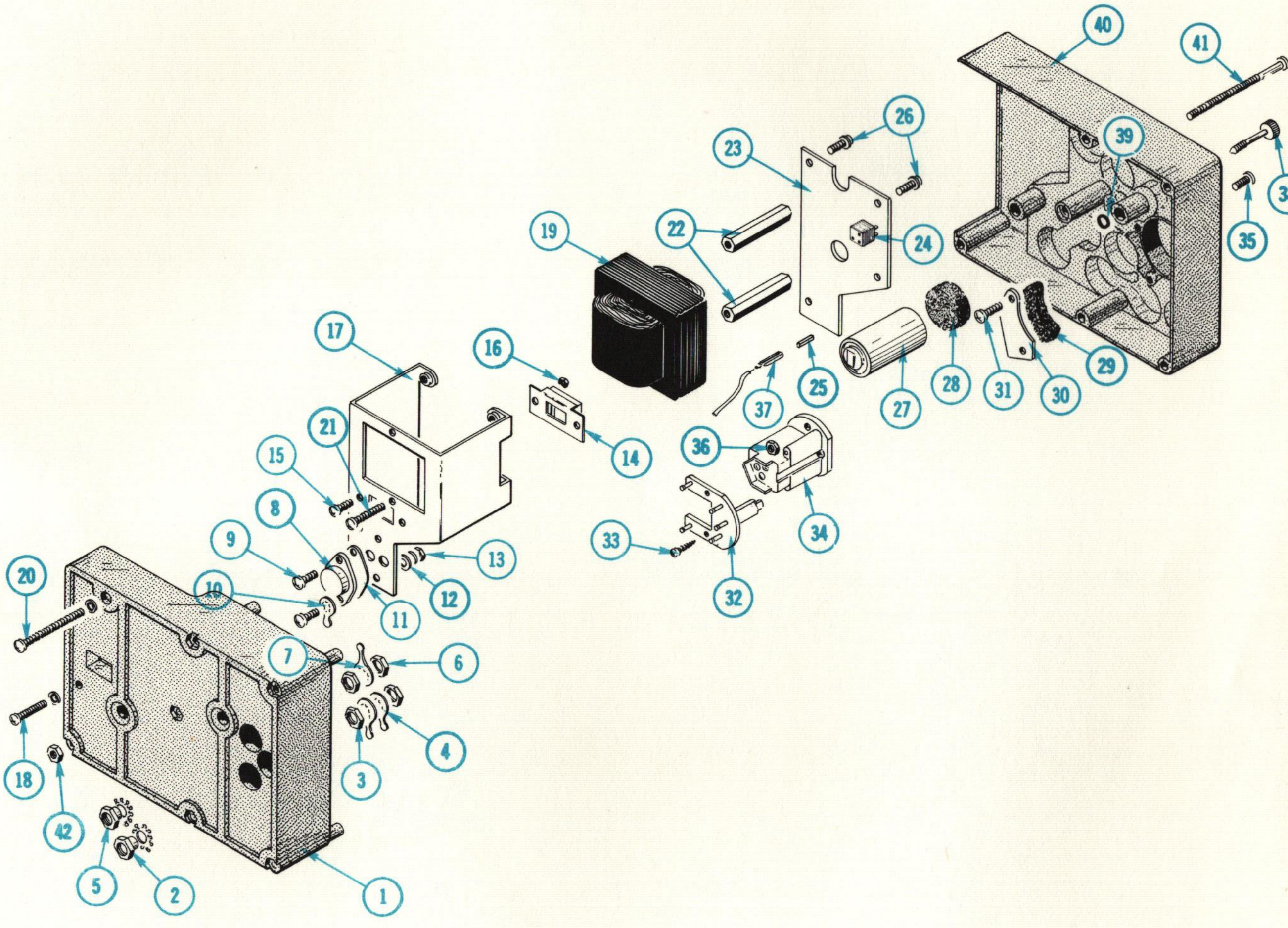
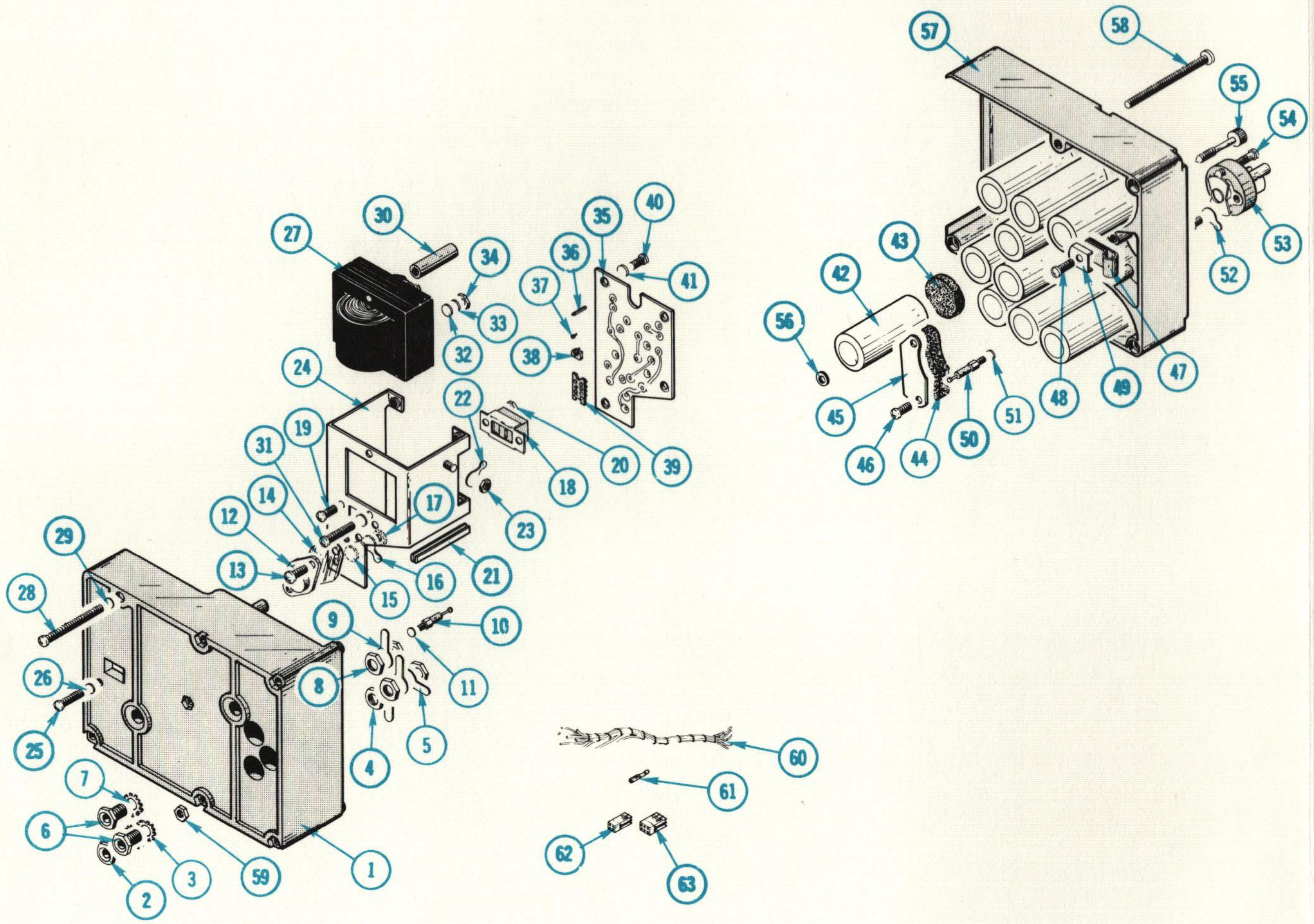


FIG. 2, 3, & 4

016-0107-02
MODEL 1 and 2



016-0107-02
MODEL 3, 4, 5, and 6

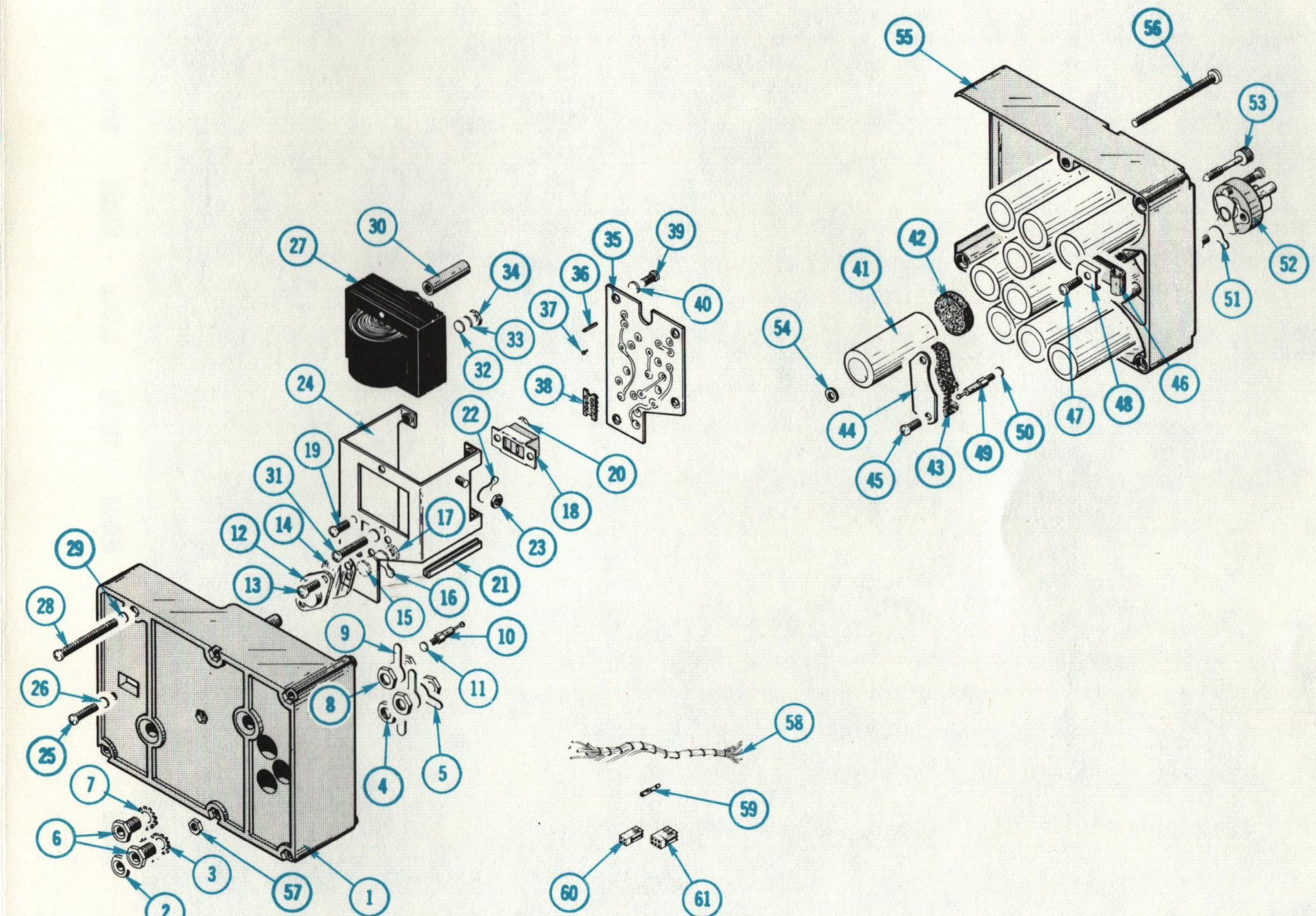


FIG. 2, 3, & 4

CRT, CABINET & HANDLE ASSEMBLY

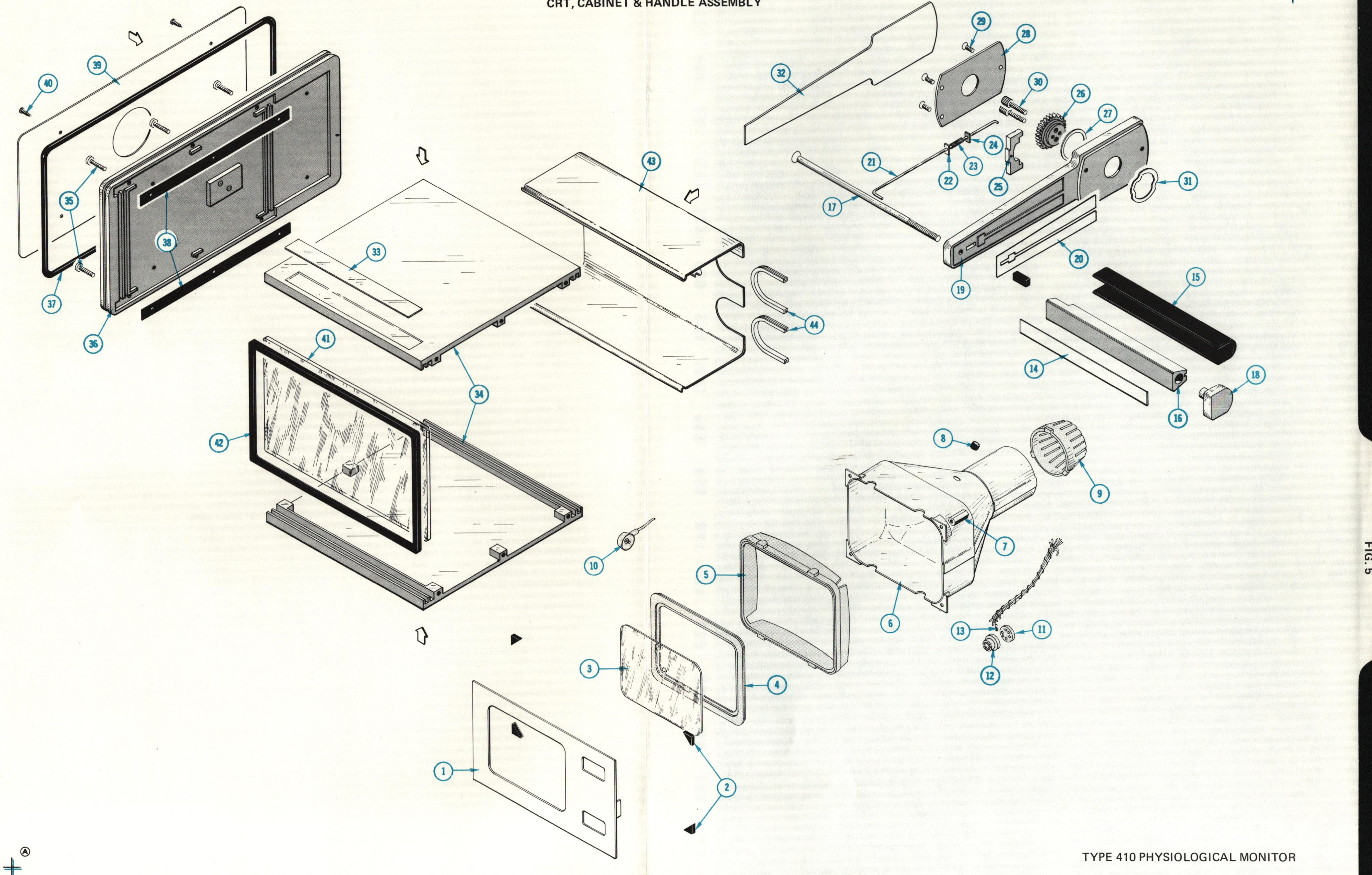


FIG. 5

CRT, CABINET & HANDLE ASSEMBLY

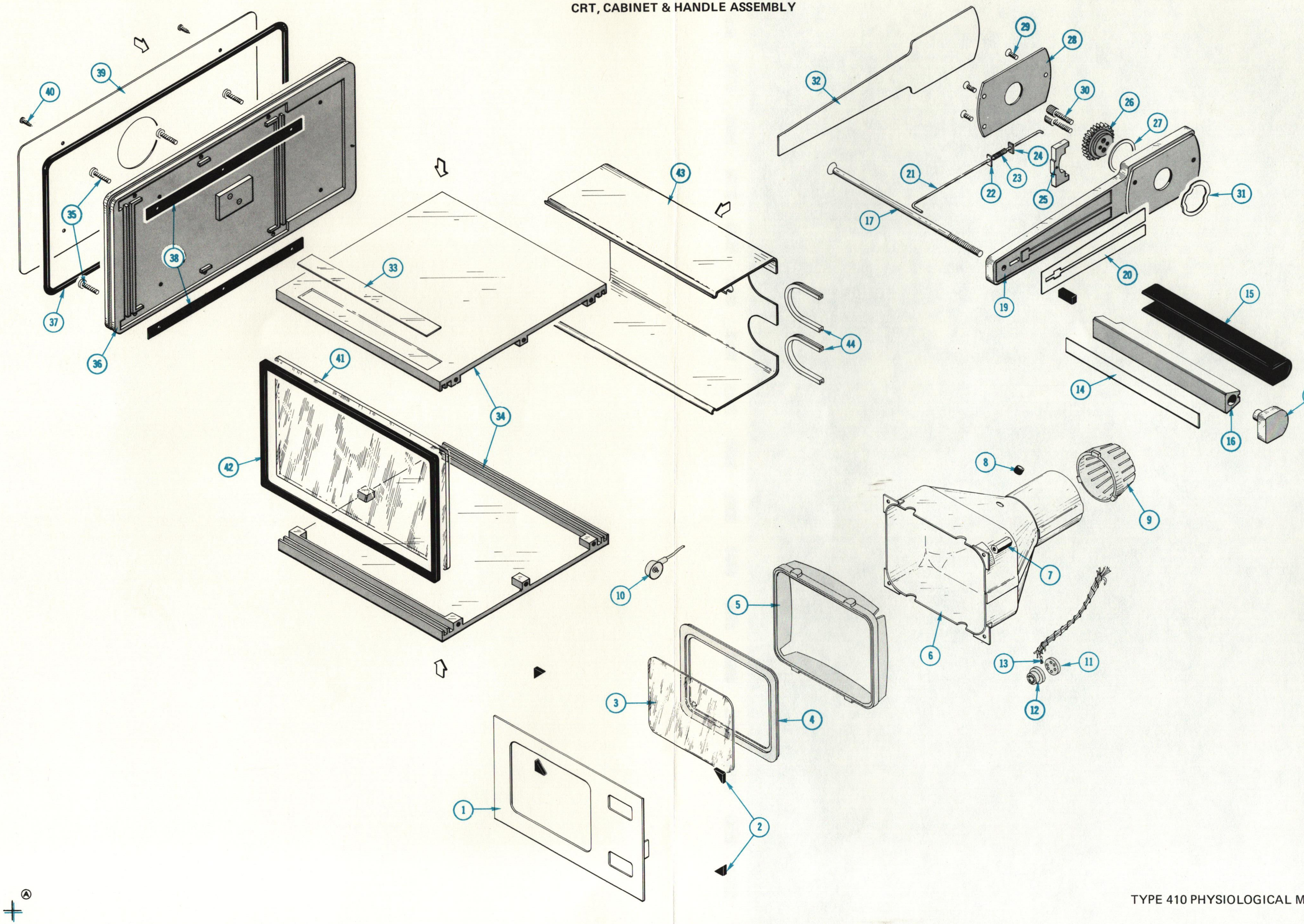


FIG. 5

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
-1	012-0120-00			1	PATIENT CABLE ASSEMBLY
-2	161-0037-01	B010100	B039999	1	CABLE ASSEMBLY, power, 8 foot
	161-0037-02	B040000	B099999	1	CABLE ASSEMBLY, power, 8 foot
	161-0058-00	B100000		1	CABLE ASSEMBLY, power, 8 foot
-3	012-0121-05	B010100	B079999	1	CABLE, patient electrode, right leg (green)
	012-0121-15	B080000	B109999	1	CABLE, patient electrode, right leg (green)
	012-0121-25	B110000		1	CABLE, patient electrode, right leg (green)
-4	012-0121-00	B010100	B079999	1	CABLE, patient electrode, left arm (black)
	012-0121-10	B080000	B109999	1	CABLE, patient electrode, left arm (black)
	012-0121-20	B110000		1	CABLE, patient electrode, left arm (black)
-5	012-0121-09	B010100	B079999	1	CABLE, patient electrode, right arm (white)
	012-0121-19	B080000	B109999	1	CABLE, patient electrode, right arm (white)
	012-0121-29	B110000		1	CABLE, patient electrode, right arm (white)
-6	012-0121-02	B010100	B079999	1	CABLE, patient electrode, left leg (red)
	012-0121-12	B080000	B109999	1	CABLE, patient electrode, left leg (red)
	012-0121-22	B110000		1	CABLE, patient electrode, left leg (red)
	103-0108-00	XB110000		5	ADAPTER, needle electrode
	012-0121-21	XB110000		1	CABLE, patient electrode, chest (brown)
-7	006-1099-00			1	RING, tape, adhesive (package of 102)
-8	006-1098-00			1	PASTE, electrode
	012-0122-00	B010100	B069999	3	KIT, electrode adapter (not shown)
	012-0122-00	B070000		2	KIT, electrode adapter (not shown)
	012-0138-00	B070000		1	KIT, electrode adapter (not shown)
	070-0658-01			1	MANUAL, instruction (not shown)

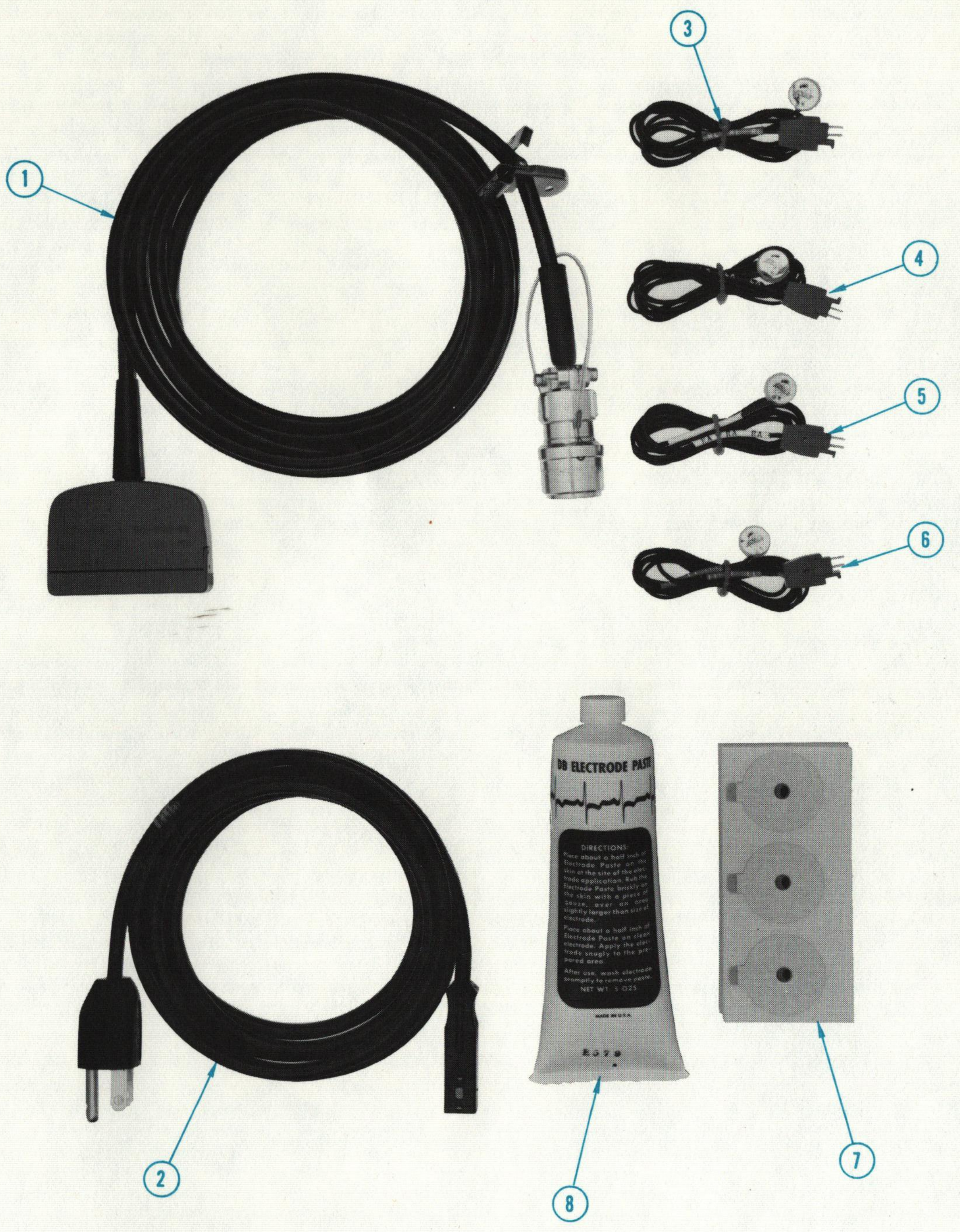
OPTIONAL ACCESSORIES

012-0121-23	1	CABLE, patient electrode, (—) EEG, yellow (not shown)
012-0121-24	2	CABLE, patient electrode, (+) EEG, yellow (not shown)
015-0104-00	1	PULSE SENSOR PACKAGE (not shown)
016-0107-00	1	BATTERY PACK (not shown)
016-0110-00	1	MOUNTING KIT (not shown)
131-0551-00	1	CONNECTOR, plug, female (not shown)
134-0079-00	1	PLUG, mini-phone (not shown)
134-0089-00	1	PLUG, 2 pin, electrode (not shown)
134-0090-00	1	PLUG, 7 pin, pulse sensor (not shown)
407-0393-01	1	BRACKET, oscilloscope (not shown)
161-0037-02	1	CABLE ASSEMBLY, power, 8 foot

Ⓖ

A

STANDARD ACCESSORIES



MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTIONS

SECTION 2 Operating Instructions

Page 2-2 Line Voltage Range

ADD: The following text and Chart at the end of the existing text.

To change nominal line voltage range taps, open the Battery Pack (see Maintenance Section, Disassembly of the Battery Pack) and connect the leads as shown in the following chart:

Lead Color / Line Voltage	Terminal	
	Gray Orange	Green Red
100 or 200 V	5	8
110 or 220 V	6	7
117 or 240 V	3	2

The Battery Pack is wired at the factory for 117-240 V operation.

NOTE

Diodes may be referred to interchangeably throughout this manual with either the circuit number prefix D, CR or VR. For example D611 is the same component as CR611, and D626 is the same as VR626.

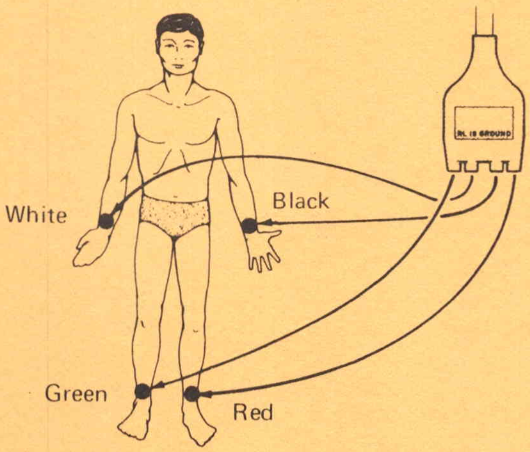
TEXT CORRECTION

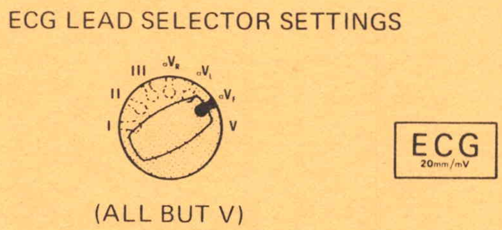
Replace the Accessories lists on Pullout Fig. 6 with the following:

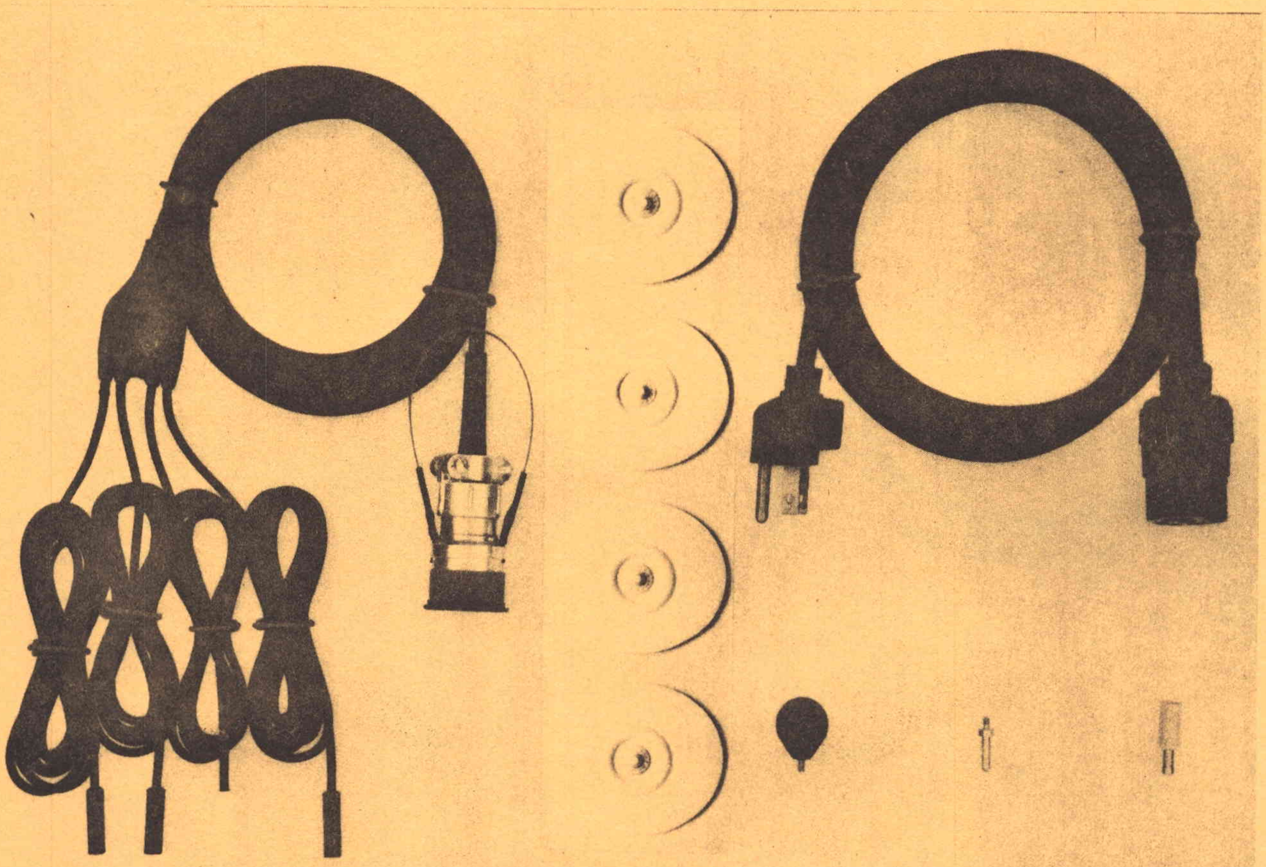
Standard Accessories (see Photo)

012-0165-00	1	CABLE ASSEMBLY, limb, lead
119-0354-00	3	ELECTRODE, disposable, pregelled (3 packs of 4 each)
103-0110-00	4	ADAPTER, snap electrode
103-0079-00	4	ADAPTER, plate
103-0108-00	4	ADAPTER, needle
161-0058-01	1	CABLE ASSEMBLY, power, 8 foot
070-0658-01	1	MANUAL, instruction (not shown)

Drawing shows standard electrode placement. Use any switch selected lead configuration except 'V'.



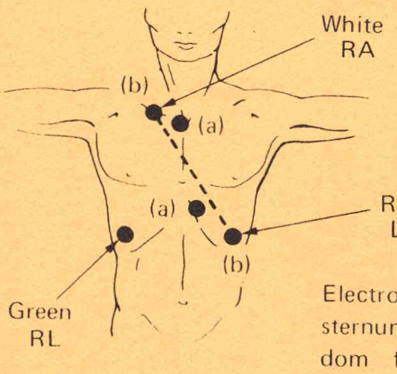




OPTION 1 Accessories (see photo)

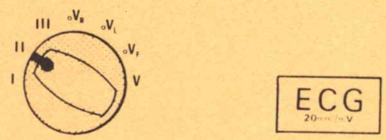
012-0161-00	1	CABLE, lead, chest
119-0353-00	3	ELECTRODE, disposable, pregelled (3 packs of 3 each)
103-0110-00	3	ADAPTER, snap electrode
103-0079-00	3	ADAPTER, plate
103-0108-00	3	ADAPTER, needle
161-0058-01	1	CABLE ASSEMBLY, power, 8 foot
070-0658-01	1	MANUAL, instruction (not shown)

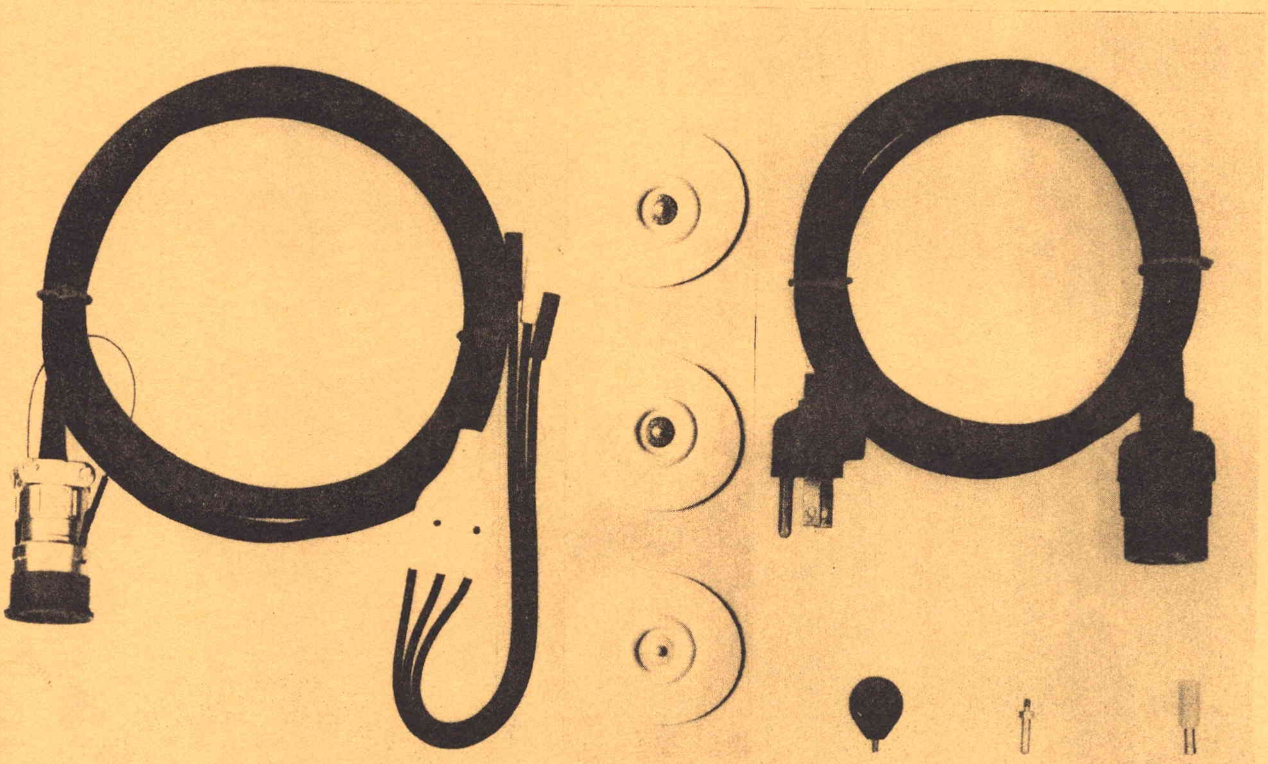
Drawing shows Chest Lead electrode placement. Switch selected lead configuration 'II' only may be used.



Electrode placement along the sternum (a) provides relative freedom from muscle artifact. To better duplicate limb connections, placement as in (b) should be used.

ECG LEAD SELECTOR SETTING





OPTION 2 Accessories

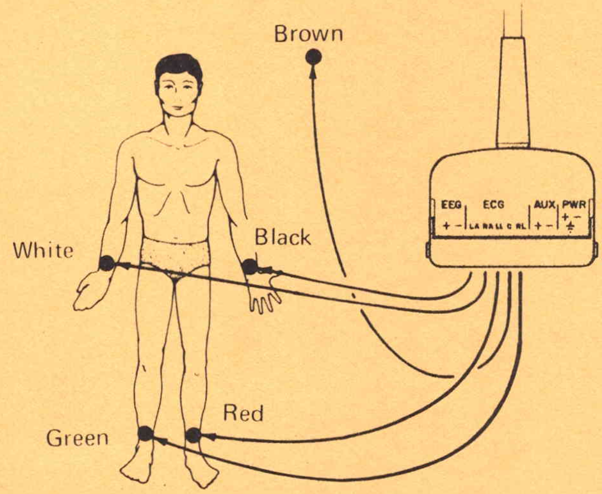
161-0058-01	1	CABLE ASSEMBLY, power, 8 foot
070-0658-01	1	MANUAL, instruction

The items listed below are available separately. The items listed previously as standard or optional accessories are not repeated here.

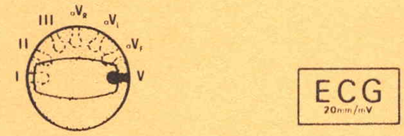
015-0104-01	PULSE SENSOR ASSEMBLY (use with Multi-Purpose cable, part number 012-0120-00).
016-0107-02	BATTERY PACK (for serial numbers B100000-up)
016-0107-00	BATTERY PACK (for serial numbers B099999-below)
407-0393-01	BRACKET, mounting
016-0110-00	MOUNTING KIT STAND (includes bracket, 407-0393-01)
134-0090-00	PLUG, 7-Pin, pulse sensor
134-0089-00	PLUG, 2-Pin, electrode (use on electrode cables which adapt to Multi-Purpose cable, part number 012-0120-00)
131-0551-01	CONNECTOR, plug, female (for rear-panel signal output)
062-1247-00	Measurement Concept Book, 'Biophysical Measurement'. A Tektronix, Inc., publication directed toward engineering personnel to familiarize the user with the electronic measurements associated with the biophysical sciences.

Cables and Electrodes

012-0120-00 Multi-Purpose Cable (for EEG and Pulse Sensor use)



ECG LEAD SELECTOR SETTINGS



(ALL SEVEN)

Electrode Cables

012-0169-00	CABLE, electrode, left arm
012-0170-00	CABLE, electrode, left leg
012-0171-00	CABLE, electrode, right arm
012-0172-00	CABLE, electrode, right leg
012-0173-00	CABLE, electrode, chest
012-0174-00	CABLE, electrode, (+) EEG
012-0175-00	CABLE, electrode, (-) EEG
103-0080-00	ADAPTER, electrode, bare wire

NOTE

Not all electrodes exhibit identical characteristics. For a detailed analysis of drift, noise, skin irritation, etc., please refer to the electrode manufacturers literature. For general information, Biophysical Measurements, Chapter 16, covers electrode characteristics.

Additional quantities of disposable pregelled pads are available in quantity and may be ordered from:

American Hospital Supply

1 each electrode Catalog Number 65375-010

NDM Corp, Dayton, Ohio

NDM Gel Pad is available as follows:

10 packs (3 pads to the pack) Catalog Number 1030

10 packs (4 pads to the pack) Catalog Number 1040